



Specifications

Fargo VA Health Care System

2101 Elm Street North

Fargo, ND 58102

EHRM Infrastructure Upgrades, Tier 2

Issue for Bid Submittal

VA Contract No. 36C26319D0044

VA Station Project No. 437-21-210

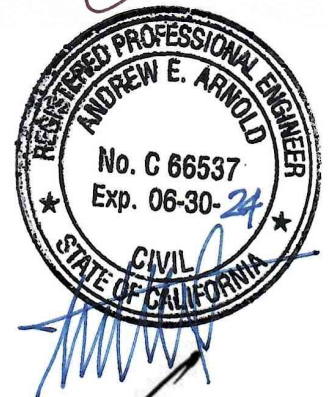
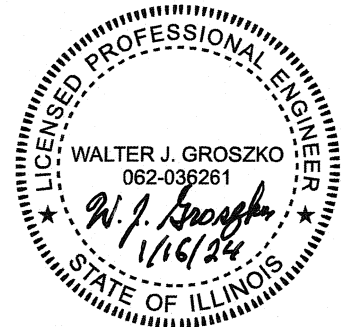
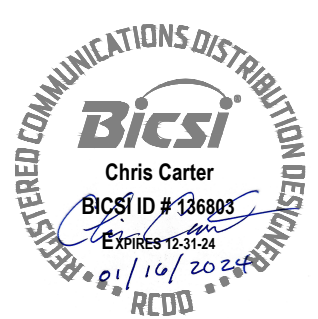
Bancroft-AE Project No. 22-113

Volume 2

Divisions 21-23, 26-28, 31-34

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DIVISION 21

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
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SECTION 21 08 00

COMMISSIONING OF FIRE SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The requirements of this Section apply to all sections of Division 21.
- B. This project will have selected building systems commissioned. The complete list of equipment and systems to be commissioned is specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. The commissioning process, which the Contractor is responsible to execute, is defined in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. A Commissioning Agent (CxA) appointed by the VA will manage the commissioning process.

1.2 RELATED WORK

- A. Section 01 00 00 GENERAL REQUIREMENTS.
- B. Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.
- C. Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

1.3 SUMMARY

- A. This Section includes requirements for commissioning the Fire Suppression systems, subsystems and equipment. This Section supplements the general requirements specified in Section 01 91 00 General Commissioning Requirements.
- B. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for more details regarding processes and procedures as well as roles and responsibilities for all Commissioning Team members.

1.4 DEFINITIONS

- A. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for definitions.

1.5 COMMISSIONED SYSTEMS

- A. Commissioning of a system or systems specified in Division 21 is part of the construction process. Documentation and testing of these systems, as well as training of the VA's Operation and Maintenance personnel in accordance with the requirements of Section 01 91 00 and of Division 21, is required in cooperation with the VA and the Commissioning Agent.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113
01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-1-16

- B. The Fire Suppression systems commissioning will include the systems listed in Section 01 91 00 General Commissioning Requirements:

1.6 SUBMITTALS

- A. The commissioning process requires review of selected Submittals. The Commissioning Agent will provide a list of submittals that will be reviewed by the Commissioning Agent. This list will be reviewed and approved by the VA prior to forwarding to the Contractor. Refer to Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, and SAMPLES for further details.
- B. The commissioning process requires Submittal review simultaneously with engineering review. Specific submittal requirements related to the commissioning process are specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CONSTRUCTION INSPECTIONS

- A. Commissioning of the building fire suppression systems will require inspection of individual elements of the fire suppression construction throughout the construction period. The Contractor shall coordinate with the Commissioning Agent in accordance with Section 01 91 00 and the Commissioning plan to schedule inspections as required to support the Commissioning Process.

3.2 PRE-FUNCTIONAL CHECKLISTS

- A. The Contractor shall complete Pre-Functional Checklists to verify systems, subsystems, and equipment installation is complete and systems are ready for Systems Functional Performance Testing. The Commissioning Agent will prepare Pre-Functional Checklists to be used to document equipment installation. The Contractor shall complete the checklists. Completed checklists shall be submitted to the VA and to the Commissioning Agent for review. The Commissioning Agent may spot check a sample of completed checklists. If the Commissioning Agent determines that the information provided on the checklist is not accurate, the Commissioning Agent will return the marked-up checklist to the Contractor for correction and resubmission. If the Commissioning Agent determines that a significant number of completed

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113
01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-1-16

checklists for similar equipment are not accurate, the Commissioning Agent will select a broader sample of checklists for review. If the Commissioning Agent determines that a significant number of the broader sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and resubmission. Refer to SECTION 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for submittal requirements for Pre-Functional Checklists, Equipment Startup Reports, and other commissioning documents.

3.3 CONTRACTORS TESTS

- A. Contractor tests as required by other sections of Division 21 shall be scheduled and documented in accordance with Section 01 00 00 GENERAL REQUIREMENTS. All testing shall be incorporated into the project schedule. Contractor shall provide no less than 7 calendar days' notice of testing. The Commissioning Agent will witness selected Contractor tests at the sole discretion of the Commissioning Agent. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.4 SYSTEMS FUNCTIONAL PERFORMANCE TESTING

- A. The Commissioning Process includes Systems Functional Performance Testing that is intended to test systems functional performance under steady state conditions, to test system reaction to changes in operating conditions, and system performance under emergency conditions. The Commissioning Agent will prepare detailed Systems Functional Performance Test procedures for review and approval by the COR. The Contractor shall review and comment on the tests prior to approval. The Contractor shall provide the required labor, materials, and test equipment identified in the test procedure to perform the tests. The Commissioning Agent will witness and document the testing. The Contractor shall sign the test reports to verify tests were performed. See Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS, for additional details.

3.5 TRAINING OF VA PERSONNEL

- A. Training of the VA operation and maintenance personnel is required in cooperation with the COR and Commissioning Agent. Provide competent, factory authorized personnel to provide instruction to operation and

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113
01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-1-16

maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. Contractor shall submit training agendas and trainer resumes in accordance with the requirements of Section 01 91 00. The instruction shall be scheduled in coordination with the COR after submission and approval of formal training plans. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS and Division 21 Sections for additional Contractor training requirements.

----- END -----

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113
01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

06-01-15

SECTION 21 13 13
WET-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Design, installation and testing shall be in accordance with NFPA 13.
- B. The design and installation of a hydraulically calculated automatic wet-pipe system complete and ready for operation, for all portions of Building _1 .
- C. Modification of the existing sprinkler system as indicated on the drawings and as further required by these specifications.
- D. Provide and install an automatic sprinkler system with zone control valve and test assembly to create a sprinkler main supply serving the Main Computer Room adjunct to the gaseous extinguishing system for that room.

1.2 RELATED WORK

- A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Section 33 10 00, WATER UTILITIES.
- C. Section 07 84 00, FIRESTOPPING.
- D. Section 09 91 00, PAINTING.
- F. Section 28 31 00, FIRE DETECTION AND ALARM.

1.3 DESIGN CRITERIA

- A. Design Basis Information: Provide design, materials, equipment, installation, inspection, and testing of the automatic sprinkler system in accordance with the requirements of NFPA 13.
 - 1. Perform hydraulic calculations in accordance with NFPA 13 utilizing the Area/Density method. Do not restrict design area reductions permitted for using quick response sprinklers throughout by the required use of standard response sprinklers in the areas identified in this section.
 - 2. Sprinkler Protection: Sprinkler hazard classifications shall be in accordance with NFPA 13. The hazard classification examples of uses and conditions identified in the Annex of NFPA 13 shall be mandatory for areas not listed below. Request clarification from the Government for any hazard classification not identified. To

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

06-01-15

determining spacing and sizing, apply the following coverage classifications:

- a. Light Hazard Occupancies: Main Computer Room, and customary access areas. Densities for Light Hazard areas shall be .10 gpm/sq. ft. over 1500 sq. ft.
 - b. Ordinary Hazard Group 1 Occupancies: Laboratories, Mechanical Equipment Rooms, Transformer Rooms, Electrical Switchgear Rooms, Electric Closets, and Repair Shops. Densities for Ordinary Group 1 areas be .15 gpm/sq. ft. over 1500 sq. ft.
 - c. Ordinary Hazard Group 2 Occupancies: Storage rooms, trash rooms, clean and soiled linen rooms, pharmacy and associated storage, laundry, kitchens, kitchen storage areas, retail stores, retail store storage rooms, storage areas, building management storage, boiler plants, energy centers, warehouse spaces, file storage areas for the entire area of the space up to 1500 square feet and Supply Processing and Distribution (SPD). Densities for Ordinary Group 2 shall be .20 gpm/sq. ft. over 1500 sq. ft.
3. Hydraulic Calculations: Calculated demand including hose stream requirements shall fall no less than 10 percent below the available water supply curve.
 4. Water Supply to this building is from an existing fire pump:
 - a. Location Fire Pump Room
 - c. Static (Suction pressure: 50 psi
 - c. Residual (Discharge) pressure: 140 psi
 - e. Date: September 11, 2023
 5. Zoning:
 - a. For each sprinkler zone provide a control valve, flow switch, and a test and drain assembly with pressure gauge. For buildings greater than two stories, provide a check valve at each control valve.
 - b. Sprinkler zones shall conform to the smoke barrier zones shown on the drawings.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

06-01-15

1.4 SUBMITTALS

A. Submit as one package in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. Prepare detailed working drawings that are signed by a NICET Level III or Level IV Sprinkler Technician or stamped by a Registered Professional Engineer licensed in the field of Fire Protection Engineering. As the Government review is for technical adequacy only, the installer remains responsible for correcting any conflicts with other trades and building construction that arise during installation. Partial submittals will not be accepted. Material submittals shall be approved prior to the purchase or delivery to the job site. Suitably bind submittals in notebooks or binders and provide an index referencing the appropriate specification section. In addition to the hard copies, provide submittal items in Paragraphs 1.4(A)1 through 1.4(A)5 electronically in pdf format on a compact disc or as directed by the COR. Submittals shall include, but not be limited to, the following:

1. Qualifications:

- a. Provide a copy of the installing contractors fire sprinkler and state contractor's license.
- b. Provide a copy of the NICET certification for the NICET Level III or Level IV Sprinkler Technician who prepared and signed the detailed working drawings unless the drawings are stamped by a Registered Professional Engineer licensed in the field of Fire Protection Engineering.
- c. Provide documentation showing that the installer has been actively and successfully engaged in the installation of commercial automatic sprinkler systems for the past ten years.

2. Drawings: Submit detailed 1:100 (1/8 inch) scale (minimum) working drawings conforming to the Plans and Calculations chapter of NFPA 13. Drawings shall include graphical scales that allow the user to determine lengths when the drawings are reduced in size. Include a plan showing the piping to the water supply test location.

3. Manufacturer's Data Sheets: Provide data sheets for all materials and equipment proposed for use on the system. Include listing information and installation instructions in data sheets. Where data

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

06-01-15

sheets describe items in addition to those proposed to be used for the system, clearly identify the proposed items on the sheet.

4. Calculation Sheets:

a. Submit hydraulic calculation sheets in tabular form conforming to the requirements and recommendations of the Plans and Calculations chapter of NFPA 13.

5. Valve Charts: Provide a valve chart that identifies the location of each control valve. Coordinate nomenclature and identification of control valves with COR. Where existing nomenclature does not exist, the chart shall include no less than the following: Tag ID No., Valve Size, Service (control valve, main drain, aux. drain, inspectors test valve, etc.), and Location.

6. Final Document Submittals: Provide as-built drawings, testing and maintenance instructions in accordance with the requirements in Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. In addition, submittals shall include, but not be limited to, the following:

a. A complete set of as-built drawings showing the installed system with the specific interconnections between the system switches and the fire alarm equipment. Provide a complete set in the formats as follows. Submit items 2 and 3 below on a compact disc or as directed by the COR.

- 1) One full size (or size as directed by the COR) printed copy.
- 2) One complete set in electronic pdf format.
- 3) One complete set in AutoCAD format or a format as directed by the COR.

b. Material and Testing Certificate: Upon completion of the sprinkler system installation or any partial section of the system, including testing and flushing, provide a copy of a completed Material and Testing Certificate as indicated in NFPA 13. Certificates shall be provided to document all parts of the installation.

c. Operations and Maintenance Manuals that include step-by-step procedures required for system startup, operation, shutdown, and routine maintenance and testing. The manuals shall include the manufacturer's name, model number, parts list, and tools that

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

06-01-15

should be kept in stock by the owner for routine maintenance, including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization, including address and telephone number, for each item of equipment.

- d. One paper copy of the Material and Testing Certificates and the Operations and Maintenance Manuals above shall be provided in a binder. In addition, these materials shall be provided in pdf format on a compact disc or as directed by the COR.
- e. Provide one additional copy of the Operations and Maintenance Manual covering the system in a flexible protective cover and mount in an accessible location adjacent to the riser or as directed by the COR.

1.5 QUALITY ASSURANCE

- A. Installer Reliability: The installer shall possess a valid State of North Dakota fire sprinkler contractor's license. The installer shall have been actively and successfully engaged in the installation of commercial automatic sprinkler systems for the past ten years.
- B. Materials and Equipment: All equipment and devices shall be of a make and type listed by UL or approved by FM, or other nationally recognized testing laboratory for the specific purpose for which it is used. All materials, devices, and equipment shall be approved by the VA. All materials and equipment shall be free from defect. All materials and equipment shall be new unless specifically indicated otherwise on the contract drawings.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. National Fire Protection Association (NFPA):
 - 13-22.....Installation of Sprinkler Systems
 - 25-22.....Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems
 - 101-22.....Life Safety Code
 - 170-22.....Fire Safety Symbols

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

06-01-15

C. Underwriters Laboratories, Inc. (UL):

Fire Protection Equipment Directory (2011)

D. Factory Mutual Engineering Corporation (FM):

Approval Guide

PART 2 - PRODUCTS

2.1 PIPING & FITTINGS

A. Piping and fittings for sprinkler systems shall be in accordance with NFPA 13.

1. Plain-end pipe fittings with locking lugs or shear bolts are not permitted.
2. Piping sizes 2 inches and smaller shall be black steel Schedule 40 with threaded end connections.
3. Piping sizes 2 ½ inches and larger shall be black steel Schedule 10 with grooved connections. Grooves in Schedule 10 piping shall be rolled grooved only.
4. Use nonferrous piping in MRI Scanning Rooms.
5. Plastic piping shall not be permitted except for drain piping.
6. Flexible sprinkler hose shall be FM Approved and limited to hose with threaded end fittings with a minimum inside diameter of 1-inch and a maximum length of 6-feet.

2.2 VALVES

A. General:

1. Valves shall be in accordance with NFPA 13.
2. Do not use quarter turn ball valves for 2 inch or larger drain valves.

B. Control Valve: The control valves shall be a listed indicating type. Control valves shall be UL Listed or FM Approved for fire protection installations. System control valve shall be rated for normal system pressure but in no case less than 175 PSI.

C. Check Valve: Shall be of the swing type with a flanged cast iron body and flanged inspection plate.

D. Automatic Ball Drips: Cast brass 3/4 inch in-line automatic ball drip with both ends threaded with iron pipe threads.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

06-01-15

2.3 FIRE DEPARTMENT SIAMESE CONNECTION (NOT USED)

2.4 SPRINKLERS

- A. In general, all sprinklers shall be FM approved quick response except "institutional" type sprinklers shall be permitted to be UL Listed quick response. Provide FM approved quick response sprinklers in all areas, except that standard response sprinklers shall be provided in the Main Computer Room area, elevator hoistways, elevator machine rooms, and generator rooms.
- B. Temperature Ratings: In accordance with NFPA 13 except that sprinklers in elevator shafts and elevator machine rooms shall be no less than intermediate temperature rated and sprinklers in generator rooms shall be no less than high temperature rated.
- C. Provide sprinkler guards in accordance with NFPA 13 and when the elevation of the sprinkler head is less than 7 feet 6 inches above finished floor. Additionally, sprinkler guards shall be provided on all automatic sprinklers in the Main Computer Room area. The sprinkler guard shall be UL listed or FM approved for use with the corresponding sprinkler.

2.5 SPRINKLER CABINET

- A. Provide sprinkler cabinet with the required number of sprinkler heads of all ratings and types installed, and a sprinkler wrench for each type of sprinkler in accordance with NFPA 13. Locate adjacent to the riser.
- B. Provide a list of sprinklers installed in the property in the cabinet. The list shall include the following:
 - 1. Manufacturer, model, orifice, deflector type, thermal sensitivity, and pressure for each type of sprinkler in the cabinet.
 - 2. General description of where each sprinkler is used.
 - 3. Quantity of each type present in the cabinet.
 - 4. Issue or revision date of list.

2.6 SPRINKLER SYSTEM SIGNAGE

Rigid plastic, steel or aluminum signs with white lettering on a red background with holes for easy attachment. Sprinkler system signage shall be attached to the valve or piping with chain.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

06-01-15

2.7 SWITCHES:

- A. OS&Y Valve Supervisory Switches shall be in a weatherproof die cast/red baked enamel, oil resistant, aluminum housing with tamper resistant screws, 1/2 inch conduit entrance and necessary facilities for attachment to the valves. Provide two SPDT switches rated at 2.5 amps at 24 VDC.
- B. Water flow Alarm Switches: Mechanical, non-coded, non-accumulative retard and adjustable from 0 to 60 seconds minimum. Set flow switches at an initial setting between 20 and 30 seconds.
- C. Valve Supervisory Switches for Ball and Butterfly Valves: May be integral with the valve.

2.8 GAUGES

Provide gauges as required by NFPA 13. Provide gauges where the normal pressure of the system is at the midrange of the gauge.

2.9 PIPE HANGERS, SUPPORTS AND RESTRAINT OF SYSTEM PIPING

Pipe hangers, supports, and restraint of system piping shall be in accordance with NFPA 13.

2.10 WALL, FLOOR AND CEILING PLATES

Provide chrome plated steel escutcheon plates.

2.11 ANTIFREEZE SOLUTION (NOT USED)

2.12 Valve Tags

Engraved black filled numbers and letters not less than 1/2 inch high for number designation, and not less than 1/4 inch for service designation on 19 gage, 1-1/2 inches round brass disc, attached with brass "S" hook, brass chain, or nylon twist tie.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be accomplished by the licensed contractor. Provide a qualified technician, experienced in the installation and operation of the type of system being installed, to supervise the installation and testing of the system.
- B. Installation of Piping: Accurately cut pipe to measurements established by the installer and work into place without springing or forcing. In any situation where bending of the pipe is required, use a standard pipe-bending template. Concealed piping in spaces that have finished

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

06-01-15

ceilings. Where ceiling mounted equipment exists, such as in operating and radiology rooms, install sprinklers so as not to obstruct the movement or operation of the equipment. Sidewall heads may need to be utilized. In stairways, locate piping as near to the ceiling as possible to prevent tampering by unauthorized personnel and to provide a minimum headroom clearance of seven feet six inches. Piping shall not obstruct the minimum means of egress clearances required by NFPA 101. Pipe hangers, supports, and restraint of system piping, shall be installed accordance with NFPA 13.

- C. Welding: Conform to the requirements and recommendations of NFPA 13.
- D. Drains: Provide drips and drains, including low point drains, in accordance with NFPA 13. Pipe drains to discharge at safe points outside of the building or to sight cones attached to drains of adequate size to readily carry the full flow from each drain under maximum pressure. Do not provide a direct drain connection to sewer system or discharge into sinks. Install drips and drains where necessary and required by NFPA 13. The drain piping shall not be restricted or reduced and shall be of the same diameter as the drain collector.
- E. Supervisory Switches: Provide supervisory switches for sprinkler control valves.
- F. Waterflow Alarm Switches: Install waterflow alarm switches and valves in stairwells or other easily accessible locations.
- G. Inspector's Test Connection: Install and supply in accordance with NFPA 13, locate in a secured area, and discharge to the exterior of the building.
- H. Affix cutout disks, which are created by cutting holes in the walls of pipe for flow switches and non-threaded pipe connections to the respective waterflow switch or pipe connection near to the pipe from where they were cut.
- I. Provide escutcheon plates for exposed piping passing through walls, floors or ceilings.
- J. Clearances: For systems requiring seismic protection, piping that passes through floors or walls shall have penetrations sized 2 inches nominally larger than the penetrating pipe for pipe sizes 1 inch to 3 ½

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

06-01-15

inches and 4 inches nominally larger for penetrating pipe sizes 4 inches and larger.

- K. Sleeves: Provide for pipes passing through masonry or concrete. Provide space between the pipe and the sleeve in accordance with NFPA 13. Seal this space with a UL Listed through penetration fire stop material in accordance with Section 07 84 00, FIRESTOPPING. Where core drilling is used in lieu of sleeves, also seal space. Seal penetrations of walls, floors and ceilings of other types of construction, in accordance with Section 07 84 00, FIRESTOPPING.
- L. Where dry pendent sprinklers are used for freezers or similar spaces and they are connected to the wet pipe system, provide an EPDM boot around the dry pendent sprinkler on the heated side and securely seal to the pipe and freezer to prevent condensation from entering the freezer.
- M. Provide pressure gauges at each water flow alarm switch location and at each main drain connection.
- N. For each fire department connection, provide the symbolic sign given in NFPA 170 and locate 8 to 10 feet above each connection location. Size the sign to 18 by 18 inches with the symbol being at least 14 by 14 inches.
- O. Firestopping shall be provided for all penetrations of fire resistance rated construction. Firestopping shall comply with Section 07 84 00, FIRESTOPPING.
- P. MRI Suite: Provide no more than one penetration of the MRI shield enclosure.
- Q. Painting of Pipe: In finished areas where walls and ceilings have been painted, paint primed surfaces with two coats of paint to match adjacent surfaces, except paint valves and operating accessories with two coats of gloss red enamel. Exercise care to avoid painting sprinklers. Painting of sprinkler systems above suspended ceilings and in crawl spaces is not required. Painting shall comply with Section 09 91 00, PAINTING. Any painted sprinkler shall be replaced with a new sprinkler.
- R. Sprinkler System Signage: Provide rigid sprinkler system signage in accordance with NFPA 13 and NFPA 25. Sprinkler system signage shall include, but not limited to, the following:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

06-01-15

1. Identification Signs:

- a. Provide signage for each control valve, drain valve, sprinkler cabinet, and inspector's test.
- b. Provide valve tags for each operable valve. Coordinate nomenclature and identification of operable valves with COR. Where existing nomenclature does not exist, the Tag Identification shall include no less than the following: (FP-B-F/SZ-#) Fire Protection, Building Number, Floor Number/Smoke Zone (if applicable), and Valve Number. (E.g., FP-500-1E-001) Fire Protection, Building 500, First Floor East, Number 001.)

2. Instruction/Information Signs:

- a. Provide signage for each control valve to indicate valve function and to indicate what system is being controlled.
- b. Provide signage indicating the number and location of low point drains.

3. Hydraulic Placards:

- a. Provide signage indicating hydraulic design information. The placard shall include location of the design area, discharge densities, required flow and residual pressure at the base of riser, occupancy classification, hose stream allowance, flow test information, and installing contractor. Locate hydraulic placard information signs at each alarm check valve.

S. Repairs: Repair damage to the building or equipment resulting from the installation of the sprinkler system by the installer at no additional expense to the Government.

T. Interruption of Service: There shall be no interruption of the existing sprinkler protection, water, electric, or fire alarm services without prior permission of the Contracting Officer. Contractor shall develop an interim fire protection program where interruptions involve occupied spaces. Request in writing at least one week prior to the planned interruption.

3.2 INSPECTION AND TEST

A. Preliminary Testing: Flush newly installed systems prior to performing hydrostatic tests in order to remove any debris which may have been left as well as ensuring piping is unobstructed. Hydrostatically test system, including the fire department connections, as specified in NFPA

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

06-01-15

13, in the presence of the Contracting Officers Representative (COR) or his designated representative. Test and flush underground water line prior to performing these hydrostatic tests.

- B. Final Inspection and Testing: Subject system to tests in accordance with NFPA 13, and when all necessary corrections have been accomplished, advise COR to schedule a final inspection and test. Connection to the fire alarm system shall have been in service for at least ten days prior to the final inspection, with adjustments made to prevent false alarms. Furnish all instruments, labor and materials required for the tests and provide the services of the installation foreman or other competent representative of the installer to perform the tests. Correct deficiencies and retest system as necessary, prior to the final acceptance. Include the operation of all features of the systems under normal operations in test

3.3 INSTRUCTIONS

Furnish the services of a competent instructor for not less than two hours for instructing personnel in the operation and maintenance of the system, on the dates requested by the COR.

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Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-15

SECTION 21 13 16
DRY-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Design, installation and testing shall be in accordance with NFPA 13.
- B. The design and installation of a hydraulically calculated automatic dry-pipe sprinkler system complete and ready for operation, for those locations as shown on the contract drawings.
- C. Modification of the existing dry-pipe sprinkler system as indicated on the drawings and as further required by these specifications.

1.2 RELATED WORK

- A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Section 33 10 00, WATER UTILITIES.
- C. Section 07 84 00, FIRESTOPPING.
- D. Section 09 91 00, PAINTING.
- E. Section 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING.
- F. Section 28 31 00, FIRE DETECTION AND ALARM.

1.3 DESIGN CRITERIA

- A. Design Basis Information: Provide design, materials, equipment, installation, inspection, and testing of the automatic sprinkler system in accordance with the requirements of NFPA 13.
 - 1. Perform hydraulic calculations in accordance with NFPA 13 utilizing the Area/Density method, including all applicable design area increases.
 - 2. Sprinkler Protection: Sprinkler hazard classifications shall be in accordance with NFPA 13. The hazard classification examples of uses and conditions identified in the Annex of NFPA 13 shall be mandatory. Request clarification from the Government for any hazard classification not identified.
 - 3. Dry-pipe Sprinkler System Volume:
 - a. Contractor shall indicate the calculated volume of each system on the sprinkler system shop drawings.
 - b. For dry-pipe sprinkler systems with volumes greater than 1893 L (500 gal) up to 2839 L (750 gal), provide a quick opening device

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-15

unless water delivery time calculations indicate the quick opening devices is not required.

- c. For dry-pipe sprinkler systems with volumes greater than 2839 L (750 gal), provide calculations for water delivery time.

Calculations shall demonstrate compliance with NFPA 13.

4. Nitrogen Generator Plant: Coordinate sizing of nitrogen generator and air compressor with the nitrogen generator manufacturer.
5. Hydraulic Calculations: Calculated demand including hose stream requirements shall fall no less than 10 percent below the available water supply curve.
6. Water Supply to this building is from an existing fire pump:
 - a. Location Fire Pump Roomb.
 - d. Static pressure (Suction Pressure): 50 psi
 - g. Date: September 11, 2023
7. Provide seismic protection in accordance with NFPA 13. Contractor shall submit load calculations for sizing of sway bracing for systems that are required to be protected against damage from earthquakes.

1.4 SUBMITTALS

- A. Submit as one package in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. Prepare detailed working drawings that are signed by a NICET Level III or Level IV Sprinkler Technician or stamped by a Registered Professional Engineer licensed in the field of Fire Protection Engineering. As the Government review is for technical adequacy only, the installer remains responsible for correcting any conflicts with other trades and building construction that arise during installation. Partial submittals will not be accepted. Material submittals shall be approved prior to the purchase or delivery to the job site. Suitably bind submittals in notebooks or binders and provide an index referencing the appropriate specification section. In addition to the hard copies, provide submittal items in Paragraphs 1.4(A)1 through 1.4(A)5 electronically in pdf format on a compact disc or as directed by the COR. Submittals shall include, but not be limited to, the following:

1. Qualifications:

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-15

- a. Provide a copy of the installing contractors fire sprinkler and state contractor's license.
 - b. Provide a copy of the NICET certification for the NICET Level III or Level IV Sprinkler Technician who prepared and signed the detailed working drawings unless the drawings are stamped by a Registered Professional Engineer licensed in the field of Fire Protection Engineering.
 - c. Provide documentation showing that the installer has been actively and successfully engaged in the installation of commercial automatic sprinkler systems for the past ten years.
2. Drawings: Submit detailed 1:100 (1/8 inch) scale (minimum) working drawings conforming to the Plans and Calculations chapter of NFPA 13. Drawings shall include graphical scales that allow the user to determine lengths when the drawings are reduced size. Include a plan showing the piping to the water supply test location.
 3. Manufacturer's Data Sheets: Provide data sheets for all materials and equipment proposed for use on the system. Include listing information and installation instructions in data sheets. Where data sheets describe items in addition to those proposed to be used for the system, clearly identify the proposed items on the sheet.
 4. Calculation Sheets:
 - a. Submit hydraulic calculation sheets in tabular form conforming to the requirements and recommendations of the Plans and Calculations chapter of NFPA 13.
 - b. For dry-pipe sprinkler systems with volumes more than 2838 L (750 gal), submit calculations for dry-pipe system water delivery time in accordance with NFPA 13.
 - c. Submit calculations of loads for sizing of sway bracing in accordance with NFPA 13.
 5. Valve Charts: Provide a valve chart that identifies the location of each control valve. Coordinate nomenclature and identification of control valves with COR. Where existing nomenclature does not exist, the chart shall include no less than the following: Tag ID No., Valve Size, Service (control valve, main drain, aux. drain, inspectors test valve, etc.), and Location.

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-15

6. Final Document Submittals: Provide as-built drawings, testing and maintenance instructions in accordance with the requirements in Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. In addition, submittals shall include, but not be limited to, the following:
- a. A complete set of as-built drawings showing the installed system with the specific interconnections between the system switches and the fire alarm equipment. Provide a complete set in the formats as follows. Submit items 2 and 3 below on a compact disc or as directed by the COR.
 - 1) One full size (or size as directed by the COR) printed copy.
 - 2) One complete set in electronic pdf format.
 - 3) One complete set in AutoCAD format or a format as directed by the COR.
 - b. Material and Testing Certificate: Upon completion of the sprinkler system installation or any partial section of the system, including testing and flushing, provide a copy of a completed Material and Testing Certificate as indicated in NFPA 13. Certificates shall be provided to document all parts of the installation.
 - c. Operations and Maintenance Manuals that include step-by-step procedures required for system startup, operation, shutdown, and routine maintenance and testing. The manuals shall include the manufacturer's name, model number, parts list, and tools that should be kept in stock by the owner for routine maintenance, including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization, including address and telephone number, for each item of equipment.
 - d. One paper copy of the Material and Testing Certificates and the Operations and Maintenance Manuals above shall be provided in a binder. In addition, these materials shall be provided in pdf format on a compact disc or as directed by the COR.
 - e. Provide one additional copy of the Operations and Maintenance Manual covering the system in a flexible protective cover and

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-15

mount in an accessible location adjacent to the riser or as
directed by the COR.

1.5 QUALITY ASSURANCE

- A. Installer Reliability: The installer shall possess a valid State of North Dakota fire sprinkler contractor's license. The installer shall have been actively and successfully engaged in the installation of commercial automatic sprinkler systems for the past ten years.
- B. Materials and Equipment: All equipment and devices shall be of a make and type listed by UL or approved by FM, or other nationally recognized testing laboratory for the specific purpose for which it is used. All materials, devices, and equipment shall be approved by the VA. All materials and equipment shall be free from defect. All materials and equipment shall be new unless specifically indicated otherwise on the contract drawings.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. National Fire Protection Association (NFPA):
- 13-2022.....Installation of Sprinkler Systems
- 25-22.....Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems
- 101-22.....Life Safety Code
- 170-22.....Fire Safety Symbols
- C. Underwriters Laboratories, Inc. (UL):
- Fire Protection Equipment Directory 2011
- D. Factory Mutual Engineering Corporation (FM):
- Approval Guide

PART 2 PRODUCTS

2.1 GENERAL

Dry-pipe sprinkler systems shall comply with the requirements of NFPA 13.

2.2 PIPING & FITTINGS

- A. Piping and fittings for private underground water mains shall be in accordance with NFPA 13.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-15

1. Pipe and fittings from inside face of building 300 mm (12 in.) above finished floor to a distance of approximately 1500 mm (5 ft.) outside building: Ductile Iron, flanged fittings and 316 stainless steel bolting.
- B. Piping and fittings for sprinkler systems shall be in accordance with NFPA 13.
 1. Plain-end pipe fittings with locking lugs or shear bolts are not permitted.
 2. Piping sizes 50 mm (2 inches) and smaller shall be black steel Schedule 40 with threaded end connections.
 3. Piping sizes 65 mm (2 ½ inches) and larger shall be black steel Schedule 10 with grooved connections. Grooves in Schedule 10 piping shall be rolled grooved only.

2.3 VALVES

A. General:

1. Valves shall be in accordance with NFPA 13.
2. Do not use quarter turn ball valves for 50 mm (2 inch) or larger drain valves.

B. Control Valve:

1. Shall be a manually operated outside stem and yoke (OS&Y) type.

C. Dry-pipe Valve:

1. Shall be a latching differential type.
2. Shall be complete with trim piping, valves, fittings, pressure gauges, priming water fill cup, velocity drip check, drip cup, and other ancillary components as required for proper operation.
3. For dry-pipe sprinkler systems with volumes more than 1893 L (500 gal), provide a quick opening device unless water delivery time calculations have proven no quick opening device is required.
4. Shall be capable of external reset.

D. Check Valve:

1. Shall be of the swing type with a flanged cast iron body and flanged inspection plate.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-15

- E. Automatic Ball Drips: Cast brass 20 mm (3/4 inch) in-line automatic ball drip with both ends threaded with iron pipe threads.
- F. Backflow Preventer: Provide backflow preventer in accordance with Section 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING. Provide means to forward flow test the backflow preventer in accordance with NFPA 13.

2.4 FIRE DEPARTMENT SIAMESE CONNECTION

- A. Brass, flush wall type, exterior fire department connection with brass escutcheon plate, sized in accordance with NFPA 13 and threaded to match the local fire protection requirements, with polished brass caps and chains. Provide escutcheon with integral raised letters "Automatic Sprinkler". Install an automatic ball drip between fire department connection and check valve with drain piping routed to the exterior of the building or a floor drain.

2.5 SPRINKLERS

- A. All sprinklers shall be FM approved. All sprinklers shall be either upright type, dry pendent type, or dry sidewall type. Provide FM Approved quick response sprinklers in all areas, except that standard response sprinklers shall be provided in freezers, refrigerators, elevator hoistways, elevator machine rooms, and generator rooms.
- B. Temperature Ratings: In accordance with NFPA 13 except that sprinklers in elevator shafts and elevator machine rooms shall be no less than intermediate temperature rated and sprinklers in generator rooms shall be no less than high temperature rated.
- C. Provide sprinkler guards in accordance with NFPA 13 and when the elevation of the head is less than 7 feet 6 inches above finished floor. The sprinkler guard shall be listed or approved for use with the corresponding sprinkler.

2.6 SUPERVISORY NITROGEN SYSTEM

- A. General:
1. Nitrogen generation and supply system shall be in accordance with NFPA 13.
- B. Nitrogen Generator Plant:
1. Provide a nitrogen supply system in accordance with the manufacturers' requirements. The system shall provide at least 98% nitrogen within the system piping.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-15

2. The nitrogen generator shall be complete with, but not limited to, air compressor, air treatment filtration, nitrogen storage tank, relief valves, check valves, isolation valves, pressure regulator, air maintenance device, and all necessary pressure controls and gauges.
 3. The air compressor shall be sized to pressurize the sprinkler system to 275 kPa (40 psi) within 30 minutes.
 4. Nitrogen concentration shall be automatically monitored for each dry-pipe sprinkler zone.
 - a. The nitrogen monitoring device shall provide a digital readout of the nitrogen concentration for each connected dry-pipe sprinkler zone.
 - b. The nitrogen monitoring device shall sample the nitrogen concentration at least once a day.
 - c. Where the nitrogen concentration is below 98%, a trouble signal shall be sent to the fire alarm system (normally open contact) and/or the building management system.
 5. A nitrogen system trouble alarm will sound when nitrogen system is in the bypass mode. Where the nitrogen system is in bypass mode, a trouble signal shall be sent to the fire alarm system (normally open contact) and/or the building management system.
 6. The nitrogen generator plant shall be wall or skid mounted.
- C. Purging Device:
1. The purging device shall shut automatically once the nitrogen concentration in the dry-pipe system piping reaches 98%.
 2. The purging device shall be of the same manufacturer as the nitrogen generator.

2.7 SUPERVISORY AIR SYSTEM

- A. Provide an air supply system in accordance with NFPA 13 and the manufacturers' requirements. The air supply system shall be sized to pressurize the sprinkler system to 275 kPa (40 psi) within 30 minutes.
- B. Air Compressor: Compressor shall be tank mounted, single stage oil-free type, air-cooled, electric-motor driven, equipped with a check valve, shutoff valve, automatic drain on drip leg, and pressure switch for automatic starting and stopping. Pressure switch settings to start and

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-15

stop the compressor shall be as required by system conditions. A safety relief valve shall be provided.

2.8 AIR PRESSURE MAINTENANCE DEVICE

Air Pressure Maintenance Device: Air pressure maintenance device shall be UL listed or FM approved and shall automatically reduce supply air pressure to provide the pressure required to be maintained in the piping system. The device shall have a cast bronze body and valve housing complete with diaphragm assembly, spring, filter, ball check to prevent backflow, 1.6 mm (1/16 inch) restriction to prevent rapid pressurization of the system, and adjustment screw. The device shall be capable of reducing an inlet pressure of up to 680 kPa (100 psig) to a fixed outlet pressure adjustable to 70 kPa (10 psig).

2.9 SPRINKLER CABINET

- A. Provide sprinkler cabinet with the required number of sprinkler heads of all ratings and types installed, and a sprinkler wrench for each type of sprinkler in accordance with NFPA 13.
- B. Provide a list of sprinklers installed in the property in the cabinet. The list shall include the following:
 - 1. Manufacturer, model, orifice, deflector type, thermal sensitivity, and pressure for each type of sprinkler in the cabinet.
 - 2. General description of where each sprinkler is used.
 - 3. Quantity of each type present in the cabinet.
 - 4. Issue or revision date of list.

2.10 SPRINKLER SYSTEM SIGNAGE

Rigid plastic, steel or aluminum signs with white lettering on a red background with holes for easy attachment. Sprinkler system signage shall be attached to the valve or piping with chain.

2.11 SWITCHES

- A. OS&Y Valve Supervisory Switches shall be in a weatherproof die cast/red baked enamel, oil resistant, aluminum housing with tamper resistant screws, 13 mm (1/2 inch) conduit entrance and necessary facilities for attachment to the valves. Provide two SPDT switches rated at 2.5 amps at 24 VDC.
- B. Alarm Pressure Switches: Activation by any flow of water equal to or in excess of the discharge from one sprinkler. The alarm pressure switch

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-15

shall be UL Listed or Factory Mutual Approved for the application in which it is used. Activation of the alarm pressure switch shall cause an alarm on the fire alarm system control unit.

- C. High/Low Pressure Supervisory Switches: The pressure switch shall be UL Listed or FM Approved and contain two single pole double throw contacts. Each switch shall be adjustable from 70 to 414 kPa (10 to 60 psi). The low pressure switch shall supervise pressure in the system and shall be set to activate at 70 kPa (10 psi) above the dry-pipe valve trip point pressure. The high pressure switch shall supervise pressure in the system and shall be set to activate at 70 kPa (10 psi) above the normal dry-pipe supervisory pressure. Activation of either high or low pressure switch shall cause a supervisory alarm on the fire alarm system control unit.

2.12 GAUGES

Provide gauges as required by NFPA 13. Provide gauges where the normal pressure of the system is at the midrange of the gauge.

2.13 PIPE HANGERS, SUPPORTS AND RESTRAINT OF SYSTEM PIPING

Pipe hangers, supports, and restraint of system piping shall be in accordance with NFPA 13.

2.14 WALL, FLOOR AND CEILING PLATES

Provide chrome plated steel escutcheon plates.

2.15 VALVE TAGS

Engraved black filled numbers and letters not less than 15 mm (1/2 inch) high for number designation, and not less than 8 mm (1/4 inch) for service designation on 19 gage, 40 mm (1-1/2 inches) round brass disc, attached with brass "S" hook, brass chain, or nylon twist tie.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be accomplished by the licensed contractor. Provide a qualified technician, experienced in the installation and operation of the type of system being installed, to supervise the installation and testing of the system.
- B. Installation of Piping: Accurately cut pipe to measurements established by the installer and work into place without springing or forcing. In any situation where bending of the pipe is required, use a standard

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-15

pipe-bending template. Conceal piping in spaces that have finished ceilings. In stairways, locate piping as near to the ceiling as possible to prevent tampering by unauthorized personnel and to provide a minimum headroom clearance of 2250 mm (seven feet six inches). Piping shall not obstruct the minimum means of egress clearances required by NFPA 101. Pipe hangers, supports, and restraint of system piping, and seismic bracing shall be installed accordance with NFPA 13.

C. Welding: Conform to the requirements and recommendations of NFPA 13.

D. Pitching of Pipe: Conform to the requirements of NFPA 13.

E. Drains: Provide drips and drains, including low point drains, in accordance with NFPA 13. Pipe drains to discharge at safe points outside of the building. Do not provide a direct drain connection to sewer system or discharge into sinks.

F. Supervisory Switches: Provide supervisory switches for sprinkler control valves to monitor closure of the valve and for high and low system supervisory air/nitrogen pressure to monitor abnormal system pressures.

G. Pressure Alarm Switches: Install alarm pressure switches in easily accessible locations.

H. Inspector's Test Connection: Install and supply in conformance with NFPA 13, and discharge to the exterior of the building. Locate test connection in an area not susceptible to mechanical damage. For dry-pipe sprinkler systems more than 2800 L (750 gal), provide the number of equivalent sprinkler outlets as calculated for water delivery time in accordance with NFPA 13.

I. Affix cutout disks, which are created by cutting holes in the walls of pipe for non-threaded pipe connections, to the respective pipe connection near to the pipe from where they were cut.

J. Provide escutcheon plates for exposed piping passing through walls, floors or ceilings.

K. Clearances: For systems requiring seismic protection, piping that passes through floors or walls shall have penetrations sized 50 mm (2 inches) nominally larger than the penetrating pipe for pipe sizes 25 mm (1 inch) to 90 mm (3 ½ inches) and 100 mm (4 inches) nominally larger for penetrating pipe sizes 100 mm (4 inches) and larger.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-15

- L. Sleeves: Provide for pipes passing through masonry or concrete. Provide space between the pipe and the sleeve in accordance with NFPA 13. Seal this space with a UL Listed through penetration fire stop material in accordance with Section 07 84 00, FIRESTOPPING. Where core drilling is used in lieu of sleeves, also seal space around penetrations. Seal penetrations of walls, floors and ceilings of other types of construction, in accordance with Section 07 84 00, FIRESTOPPING.
- M. For each fire department connection, provide the symbolic sign given in NFPA 170 and locate 2400 to 3000 mm (8 to 10 feet) above each connection location. Size the sign to 450 by 450 mm (18 by 18 inches) with the symbol being at least 350 by 350 mm (14 by 14 inches).
- N. Firestopping shall be provided for all penetrations of fire resistance rated construction. Firestopping shall comply with Section 07 84 00, FIRESTOPPING.
- O. Painting of Pipe: In finished areas where walls and ceilings have been painted, paint primed surfaces with two coats of paint to match adjacent surfaces, except paint valves and operating accessories with two coats of gloss red enamel. Exercise care to avoid painting sprinklers. Painting of sprinkler systems above suspended ceilings and in crawl spaces is not required. Painting shall comply with Section 09 90 00, PAINTING. Any painted sprinkler shall be replaced with a new sprinkler.
- P. Locate sprinkler cabinet adjacent to the dry-pipe sprinkler system riser or as directed by COR.
- Q. Sprinkler System Signage: Provide rigid sprinkler system signage in accordance with NFPA 13 and NFPA 25. Sprinkler system signage shall include, but not limited to, the following:
1. Identification Signs:
 - a. Provide signage for each control valve, drain valve, sprinkler cabinet, and inspector's test.
 - b. Provide valve tags for each operable valve. Coordinate nomenclature and identification of operable valves with COR. Where existing nomenclature does not exist, the Tag Identification shall include no less than the following: (FP-B-F/SZ-#) Fire Protection, Building Number, Floor Number/Smoke Zone

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-15

(if applicable), and Valve Number. (E.g., FP-500-1E-001) Fire
Protection, Building 500, First Floor East, Number 001.)

2. Instruction/Information Signs:

- a. Provide signage for each control valve to indicate valve function and to indicate what system is being controlled.
- b. Provide signage indicating the number and location of low point drains.

3. Hydraulic Placards:

- a. Provide signage indicating hydraulic design information. The placard shall include location of the design area, discharge densities, required flow and residual pressure at the base of riser, occupancy classification, hose stream allowance, flow test information, and installing contractor. Locate hydraulic placard information signs at each dry-pipe valve.

R. Repairs: Repair damage to the building or equipment resulting from the installation of the sprinkler system by the installer at no additional expense to the Government.

S. Interruption of Service: There shall be no interruption of the existing sprinkler protection, water, electric, or fire alarm services without prior permission of the Contracting Officer Representative. Contractor shall develop an interim fire protection program where interruptions involve in occupied spaces. Request in writing at least one week prior to the planned interruption.

3.2 INSPECTION AND TEST

A. Preliminary Testing: Flush newly installed systems prior to performing tests in order to remove any debris which may have been left as well as ensuring piping is unobstructed. Manually demonstrate nitrogen concentration in dry-pipe sprinkler system piping is at least 98%. Hydrostatically test system, including the fire department connections, pneumatically test system, test air compressor fill time to operating pressure within 30 minutes, and trip test system as specified in NFPA 13, in the presence of the Contracting Officers Representative (COR) or their designated representative. For dry-pipe sprinkler systems with a quick-opening device, the system shall be trip tested with the quick-opening device functioning and with the quick-opening device disabled.

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-15

Record the time to water delivery for each test. Demonstrate pitch of pipe is in compliance with NFPA 13.

- B. Final Inspection and Testing: Subject system to tests in accordance with NFPA 13, and when all necessary corrections have been accomplished, advise COR to schedule a final inspection and test. Connection to the fire alarm system shall have been in service for at least ten days prior to the final inspection, with adjustments made to prevent false alarms. Furnish all instruments, labor and materials required for the tests and provide the services of the installation foreman or other competent representative of the installer to perform the tests. Correct deficiencies and retest system as necessary, prior to the final inspection and testing. Include the operation of all features of the systems under normal operations in test. At the conclusion of final inspection and testing, blow out dry-pipe system piping using compressed air. Verify piping is fully drained, including low point drains.
- C. Post-Final Inspection: One month after final inspection and testing, the contractor shall manually verify that the system piping has a nitrogen concentration of at least 98%. Advise COR to schedule post-final inspection.
- D. Final Contractual Acceptance: Final contractual acceptance will be given after successful completion of the final inspection and testing and post-final inspection. The warranty period shall begin after final contractual acceptance.

3.3 INSTRUCTIONS

Furnish the services of a competent instructor for not less than two hours for instructing personnel in the operation and maintenance of the system on the dates requested by the COR.

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Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-15

SECTION 21 22 00

CLEAN AGENT FIRE SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Design, installation and testing of a calculated automatic and manual fixed total flooding clean agent fire extinguishing system and releasing system in accordance with NFPA 2001, NFPA 72, NFPA 70, and NFPA 75 and manufacturer's written instructions for the locations shown on the contract drawings. The installation shall include all mechanical, controls and electrical components necessary for a complete and operating clean agent fire suppression system.

1.2 RELATED WORK

- A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES
B. Section 07 84 00, FIRESTOPPING
C. Section 09 91 00, PAINTING
D. Section 28 05 13, CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY
E. Section 28 05 28.33, CONDUIT AND BACKBOXES FOR ELECTRONIC SAFETY AND SECURITY
F. Section 28 31 00, FIRE DETECTION AND ALARM

1.3 DESIGN CRITERIA

- A. The clean agent fire extinguishing system shall be a fixed total flooding type utilizing clean agent designed to provide a uniform concentration throughout the protected spaces in accordance with NFPA 2001 for a Class C fire.
1. The system shall provide a minimum design concentration by volume, throughout the protected spaces at the minimum anticipated temperature within the protected space.
 2. The design concentration within any protected space shall not exceed by volume the no observable adverse effects level (NOAEL). Special means such as mechanical exhaust, shall not be permitted to be used to achieve this criterion.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-15

3. The clean agent shall have a global warming potential (GWP) of less than 4000 and the clean agent shall be readily available throughout the continental United States.
4. Provide the quantity of clean agent as required by NFPA 2001 and manufacturer's written instructions. Such factors as unenclosed openings (if any), "rundown" time of fans, time required for dampers to close, and any other feature of the facility that could affect concentration shall be taken into consideration.

1.4 SUBMITTALS

- A. Submit as one package in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. Prepare detailed working drawings that are signed by a NICET Level IV Special Hazards Suppression Systems Technician. As the Government review is for technical adequacy only, the installer remains responsible for correcting any conflicts with other trades and building construction that arise during installation. Partial submittals will not be accepted. Material submittals shall be approved prior to the purchase or delivery to the job site. Suitably bind submittals in notebooks or binders and provide an index referencing the appropriate specification section. In addition to the hard copies, provide submittal items in Paragraphs 1.4 (A) 1 through 1.4 (A) 5 electronically in pdf format on a compact disc or as directed by the Contracting Officers Representative (COR). Submittals shall include, but not be limited to, the following:

1. Qualifications:

- a. Provide a copy of the installing contractors Special Suppression Systems and state contractors license.
- b. Provide a copy of the NICET certification for the NICET Level IV Special Hazards Suppression System Technician who will prepare and sign the detailed working drawings.
- c. Provide documentation showing that the installer has been actively and successfully engaged in the installation of clean agent fire suppression systems for the past ten years.

2. Drawings: Submit detailed 1:100 (1/8 inch) scale (minimum) working plans and drawings of the clean agent fire extinguishing system conforming to NFPA 2001. Submit detailed 1:100 (1/8 inch) scale (minimum) working plans and drawings of the releasing system

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-15

conforming to NFPA 72. Drawings shall include graphical scales that allow the user to determine lengths when the drawings are reduced in size.

3. Manufacturers Data Sheets:

a. Provide for all materials and equipment proposed for use on the clean agent fire extinguishing system, including the releasing system. Include listing information and installation instructions in data sheets. Where data sheet describes items in addition to that item being submitted, clearly identify proposed item on the sheet.

4. Calculation Sheets:

a. Submit flow calculation sheets in tabular form conforming to the requirements of NFPA 2001. Calculations shall include total storage capacity, flooding concentrations, enclosure leakage rates, discharge times, flow through distribution network, pipe sizes, and nozzle orifice sizes.

b. Submit battery calculations sheets in tabular form conforming to the requirements of NFPA 72.

c. Submit voltage drop calculations in tabular form. Calculations shall indicate circuit amperage draw, wire resistance, circuit length, and voltage drop. The voltage drop shall demonstrate that voltage provided at the each appliance is within its operating voltage range. Voltage drop calculations shall assume an initial voltage of 20.4 volts.

5. Clean Agent Recharging Certification: Provide a letter to the COR or his designated representative certifying that the installer maintains or has access to a clean agent recharging station. The installer shall also provide proof of the ability to recharge the largest clean agent fire extinguishing system capacity within 48 hours.

6. Test Plan: Provide a test plan to the COR or his designated representative. The testing plan shall describe the procedures to be used to test the system. The testing plan shall include a step-by-step procedure of all tests to be performed, including indication of which tests will present a disruption to building occupants. No

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-15

tests shall be conducted until the testing plan is approved by the COR or his designated representative.

7. Final Document Submittals: Provide as-built drawings, testing and maintenance instructions in accordance with the requirements in Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. Submittals shall include, but not be limited to, the following:
- a. A complete set of as-built drawings showing the installed system with the specific interconnections between the system switches and the fire alarm equipment. Provide a complete set in the formats as follows. Submit items 2 and 3 below on a compact disc or as directed by the COR.
 - 1) One full size (or size as directed by the COR) printed copy.
 - 2) One complete set in electronic pdf format.
 - 3) One complete set in AutoCAD format or a format as directed by the COR.
 - b. System Certification: Upon completion of the clean agent fire extinguishing system installation, including testing, the authorized representative of the manufacturer of the major equipment shall certify that the installation complies with all manufacturer's requirements and that satisfactory total system operation has been achieved. Provide a copy of the Record of Completion for the releasing system in accordance with NFPA 72.
 - c. Operating and Maintenance Manuals that include step-by-step procedures required for operation, shutdown, and routine maintenance and testing. The manuals shall include the manufacturer's name, model number, parts list, the name of the local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization, including address and telephone number, for each item of equipment.
 - d. One paper copy of the System Certification and Record of Completion and the Operating and Maintenance Manuals listed above shall be provided in a binder. In addition, these materials shall be provided in pdf format on a compact disc or as directed by the COR.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-15

- e. Provide one additional copy of the Operations and Maintenance Manual for the system in a binder and mount in an accessible location adjacent to the storage cylinder(s).

1.5 QUALITY ASSURANCE

- A. Installer Reliability: The installer shall possess a valid State of North Dakota Special Suppression Systems contractor's license. The installer shall have been actively and successfully engaged in the installation of clean agent special suppression systems for the past ten years. The installer shall maintain or have access to a clean agent recharging station. The installer shall provide proof of the ability to recharge the largest clean agent fire extinguishing system capacity within 48 hours.
- B. Materials and Equipment: All equipment and devices shall be UL listed or approved by FM. All materials, devices, and equipment shall be approved by the VA. All materials and equipment shall be free from defect.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. National Fire Protection Association (NFPA):
- 70-2022.....National Electric Code
 - 72-2022.....National Fire Alarm Code
 - 75-2020.....Fire Protection of Information Technology
Equipment
 - 170-2021.....Fire Safety Symbols
 - 2001-2022.....Installation of Clean Agent Fire Extinguishing
Systems
- C. Underwriters Laboratories, Inc. (UL):
- 2011..... Fire Protection Equipment Directory
- D. Factory Mutual Engineering Corporation (FM):
- 2015..... Approval Guide

1.7 WARRANTY

All work performed and all material and equipment furnished under this contract shall be free from defects and shall remain so for a period of

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-15

one year from the date of acceptance of the entire installation by the
COR.

PART 2 PRODUCTS

2.1 GENERAL

All equipment and components shall be new and the manufacturer's current model. All equipment and components shall be UL listed or FM approved for its intended use. The authorized representative of the manufacturer of the major equipment shall certify that the installation complies with all manufacturer's requirements and that satisfactory total system operation has been achieved.

2.2 CLEAN AGENT FIRE EXTINGUISHING SYSTEM

A. General:

1. The clean agent fire extinguishing system shall be UL listed and shall be in accordance with NFPA 2001.

B. Piping and fittings:

1. All piping and fittings shall be in compliance with NFPA 2001.
2. Multi-outlet fittings, other than tees, shall not be permitted.
3. All piping shall be reamed, blown clear, and swabbed with appropriate solvent to remove mill varnish and cutting oils before assembly.
4. Ordinary cast iron steel and non-metallic piping and fittings and flexible hoses shall not be used unless specifically required by the manufacturer.

C. Piping Support:

1. All piping shall be supported in accordance with the manufacturer's written instructions.
2. Piping shall be supported within 12 inches of discharge nozzles. The supports shall prevent the upward movement of the nozzle.

D. Storage Cylinders:

1. Provide storage cylinders as required by the manufacturer's written instructions and in accordance with NFPA 2001.
2. Cylinder assemblies shall be of steel construction designed to meet the requirements of the U.S. Department of Transportation.
3. Filling of the storage cylinders shall be by an authorized systems distributor in conjunction with a factory authorized agent filling

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-15

station. Initial filling and recharge shall be performed in accordance with manufacturer's written instructions and shall not require replacement components for normal service.

4. Cylinders shall be securely attached to the wall. Provide factory- or field-fabricated retaining brackets consisting of steel straps and channels; suitable for container support, maintenance, and tank refilling or replacement.
5. For halocarbon clean agents, storage cylinders shall be provided with a low agent pressure switch.

E. Valve Actuators:

1. Electric valve actuators shall be of brass construction and stackable design with swivel connections to allow removal of actuators for maintenance or testing.
2. Operation of actuators shall not require replacement of components. No electro-explosive devices may be used to actuate the valve assembly. Actuators shall include an indication if they are set or actuated.
3. Electric valve actuators shall be magnetic latch, continuous duty type for 24 VDC operation.
4. Actuation devices shall be UL listed or FM approved for use with the system.
5. Removal of the electric valve actuator shall cause a trouble on the clean agent control panel.

F. Discharge Nozzles:

1. Nozzles shall be permanently marked with the manufacturer's part number. The nozzles shall be threaded directly to the discharge piping without the use of special adaptors.

2.3 RELEASING SYSTEM

A. General

1. The releasing system shall be an analog addressable intelligent reporting, microprocessor controlled system, capable of remote sensitivity testing of the smoke detectors, and be installed in accordance with NFPA 70, NFPA 72, and NFPA 2001.

B. Clean Agent Control Panel:

1. General:

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-15

- a. The clean agent control panel shall be UL listed or FM approved and include a UL listed or FM approved releasing module.
 - b. Each protected space shall be provided with its own clean agent control unit.
 - c. All circuits shall be monitored for integrity.
 - d. Visually and audibly annunciate all alarm, supervisory, and trouble signals including, but not limited to main power failure, open circuit, short circuit, ground faults, and system bypass activation.
 - e. The panel or releasing module shall include a 0-60 second programmable timer.
 - f. The clean agent control panel shall be provided with separate contacts to provide common supervisory, alarm, and trouble signals to the main building fire alarm system.
2. Enclosure:
- a. The clean agent control unit shall be housed in a cabinet suitable for both recessed and surface mounting. The cabinet and front panel shall be corrosion protected, given a rust-resistant prime coat, and manufacturer's standard finish.
 - b. The cabinet shall contain all necessary relays, terminals, lamps, and legend plates to provide control for the system.
3. Power Supply:
- a. The clean agent control unit shall derive its normal power from a 120 volt, 60 Hz dedicated supply connected to the emergency power system. Standby power shall be provided by a 24 volt DC battery as hereinafter specified. The normal power shall be transformed, rectified, coordinated, and interfaced with the standby battery and charger.
 - b. The power supply for smoke detection systems shall be taken from the clean agent control unit.
4. Circuit Supervision: Each alarm initiating device circuit, signaling line circuit, and notification appliance circuit, shall be supervised against the occurrence of an open, short circuit, or ground fault condition in the field wiring. These conditions shall cause a trouble signal to sound in the control unit until manually silenced by an off switch.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-15

- a. Initiating device circuits (IDC) shall be wired Class B in accordance with NFPA 72.
 - b. Signaling line circuits (SLC) shall be wired Class B in accordance with NFPA 72.
 - c. Notification appliance circuits (NAC) shall be wired Class B in accordance with NFPA 72.
5. Supervisory Alarm Devices: The low agent pressure switch and maintenance lock-out switch shall initiate a supervisory signal.
6. Trouble signals:
- a. Arrange the trouble signals for automatic reset (non-latching).
 - b. System trouble switch off and on lamps shall be visible through the control unit door.
7. Function Switches: Provide the following switches in addition to any other switches required for the system:
- a. Remote Alarm Transmission By-pass Switch: Shall prevent transmission of all signals to the building fire alarm control unit when in the "off" position. A clean agent control unit system trouble signal shall be energized when switch is in the off position.
 - b. Alarm Off Switch: Shall disconnect power to notification appliance circuits on the clean agent control panel. A system trouble signal shall be activated when the switch is in the off position.
 - c. Trouble Silence Switch: Shall silence the trouble signal whenever the trouble silence switch is operated. This switch shall not reset the trouble signal.
 - d. Reset Switch: Shall reset the system after an alarm, provided the initiating device has been reset. The system shall lock in alarm until reset.
 - e. Lamp Test Switch: A test switch or other approved convenient means shall be provided to test the indicator lamps.
 - f. AHU By-Pass: Provide a means to disable air handling units shutdown and dampers from closing upon operation of an initiating device designed to interconnect with these devices. A system trouble signal shall be activated when switch is in the off position.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-15

8. Reset2 Capability: Each clean agent control unit shall be installed and programmed so that each must be reset locally after an alarm, before the main fire alarm control unit can be reset.

C. Conduit, Boxes, and Wire

1. Conduit shall be in accordance with Section 28 05 28.33 CONDUIT AND BACKBOXES FOR ELECTRONIC SAFETY AND SECURITY and as follows:

- a. All new conduits shall be installed in accordance with NFPA 70.
- b. Conduit fill shall not exceed 40 percent of interior cross sectional area.
- c. All new conduits shall be 3/4 inch minimum.

2. Wire:

- a. Wiring shall be installed in conduit.
- b. Wiring shall be in accordance with NEC article 760, Section 28 05 13, CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY, and as recommended by the manufacturer of the fire alarm system. All wires shall be color coded. Number and size of conductors shall be as recommended by the fire alarm system manufacturer, but not less than 18 AWG for initiating device circuits and 14 AWG for notification appliance circuits.
- c. Signaling line circuits shall be twisted and shielded unless other wiring methods are specifically required by the fire alarm equipment manufacturer in writing.

3. Terminal Boxes, Junction Boxes, and Cabinets:

- a. These shall be galvanized steel in accordance with UL requirements.
- b. All boxes shall be sized and installed in accordance with NFPA 70.
- c. Covers shall be repainted red in accordance with Section 09 91 00, PAINTING and shall be identified with white markings as "CA FA" or as directed by the COR for junction boxes and as "CLEAN AGENT FIRE ALARM SYSTEM" for cabinets and terminal boxes. Lettering shall be a minimum of 3/4 inch high.
- d. Terminal boxes and cabinets shall have a volume 50 percent greater than required by NFPA 70. Minimum sized wire shall be considered as 14 AWG for calculation purposes.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-15

- e. Terminal boxes and cabinets shall have identified screw type terminal strips and shall be located in an accessible location. Terminal strips shall be labeled as to what circuit it is or as approved by the COR.

D. Standby Power Supply

1. Batteries:

- a. The batteries shall be of the sealed, maintenance free type, 24-volt nominal.
- b. The batteries shall have sufficient capacity to power the clean agent control panel and its peripherals for not less than 24 hours plus 5 minutes of alarm to an end voltage of 1.14 volts per cell, upon a normal AC power failure.
- c. Battery racks shall be steel with an alkali-resistant finish.

2. Battery Charger:

- a. The battery charger shall be completely automatic, with constant potential charger maintaining the battery fully charged under all service conditions. Charger shall operate from a 120-volt, 60 hertz emergency power source.
- b. The battery charger shall be rated for fully charging a completely discharged battery within 48 hours while simultaneously supplying any loads connected to the battery.
- c. The battery charger shall have protection to prevent discharge through the charger.
- d. The battery charger shall have protection for overloads and short circuits on both AC and DC sides.
- e. A trouble condition shall actuate the fire alarm trouble signal.
- f. The battery charger shall have automatic AC line voltage regulation, automatic current-limiting features, and adjustable voltage controls.

E. Spot-type Smoke Detectors

- 1. Smoke detectors shall be photoelectric plug-in type and UL listed for use with the clean agent control panel being furnished. Each detector shall be monitored individually, via an integral, analog addressable element.
- 2. Photoelectric detectors shall be factory calibrated and readily field adjustable. The sensitivity of any photoelectric detector

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-15

- shall be factory set at 3.0 plus or minus 0.25 percent obscuration per foot.
3. Smoke detectors of the protected spaces shall be spaced in accordance with NFPA 72 for high air movement areas. Air velocities within the protected spaces shall be suitable for the listed detection air velocity range of the smoke detector.
 4. Each protected space shall have at least 2 detectors.
 5. Provide red stickers with an "A" on the ceiling below the location of the above ceiling smoke detectors when above ceiling detectors are provided. Provide red stickers with a "U" on the ceiling above the location of the under floor smoke detectors. Each sticker shall also include the address of the detector. The address shall be the same as that address that shows on the fire alarm control unit when the detector is activated.
 6. For smoke detectors located under the floor, the smoke detectors shall be mounted with a steel angle or channel support independent of the raised floor structure. The smoke detectors shall be mounted in a vertical orientation.

F. Manual Activation Stations:

1. Shall be non-break glass, address reporting type.
2. Station front shall be constructed of durable material such as cast or extruded metal or high impact plastic. Stations shall be semi-flush type.
3. Shall be of dual action pull down type with suitable operating instructions provided on front in raised or depressed letters, and clearly labeled "AGENT RELEASE."
4. Operating handles shall be constructed of a durable material. On operation, the lever shall lock in alarm position and remain so until physically reset. A key shall be required to gain front access for resetting, or conducting tests and drills.
5. Shall be located at least 3.28 ft from any fire alarm manual pull station.

G. Notification Appliances:

1. Pre-discharge Bells:
 - a. Shall be 24 VDC and be capable of producing an alarm signal of not less than 85 dBA at 10 feet.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-15

- b. Shall be at least 6 inches in diameter.
- 2. Pre-discharge Strobes:
 - a. Be listed in accordance with UL 1971.
 - b. Shall be a minimum of 75 candela.
 - c. Shall be provided with an amber lens.
 - d. Shall be synchronized with other pre-discharge strobes in the protected space.
- 3. Discharge Strobes:
 - a. Be listed in accordance with UL 1971.
 - b. Shall be a minimum of 75 candela.
 - c. Shall be provided with a red lens.
 - d. Shall be synchronized with other discharge strobes outside the protected space.
- H. Addressable Interface Module
 - 1. Addressable interface modules shall be installed in individual boxes in accordance with the manufacturer's product listing. The addressable interface module shall be provided with a protective cover provided by the device manufacturer. The protective cover shall have the provision for viewing the operational LED of the addressable interface module. Addressable interface modules shall not be installed in a back-box with other devices or relays.
 - 2. The installer shall provide, install, and test addressable interface modules as necessary to comply with the sequence of operations, whether shown on the drawings or not.
- I. Graphic Floor Plans:
 - 1. Provide readable scaled graphics of the protected area. The graphics shall show the location and address of each the ceiling smoke detectors, above ceiling smoke detectors, and under floor smoke detectors, on separate plans.
 - 2. The graphic shall be framed and shall be located in an area approved by the COR.
 - 3. Where approved by the COR a single graphic floor plan shall be permitted.
- J. Abort Switches:

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-15

1. The abort switch front shall be constructed of durable material such as cast or extruded metal or high impact plastic. The abort switch shall be semi-flush type.
2. The abort switch shall not be a locking or keyed type.
3. The abort switch shall be of single action dead-man spring loaded type with suitable operating instructions provided on front in raised or depressed letters, and clearly labeled "ABORT."

2.4 SWITCHES

A. Maintenance Lock-out Switch

1. Shall be key-operated only allowing the removal of the key in the "Normal" position. A red indicator lamp shall be included on the switch assembly to be illuminated when in the "Lock-out" position. The clean agent control panel shall indicate a supervisory alarm condition when in the "Lock-out" position.
2. The terminals shall be of the screw type.
3. Shall be provided adjacent to the clean agent control panel.

2.5 SIGNAGE

- A. Signage shall have white lettering on a red plastic background.
- B. The letters shall be 1 inch high with a stroke width of 3/8 inches.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be accomplished by the licensed contractor. Provide a factory trained qualified technician, experienced in the installation and operation of the type of system being installed, to supervise the installation and testing of the system.
- B. Install clean agent fire extinguishing system piping and fittings level and plumb, according to manufacturer's written instructions.
- C. Where installing piping adjacent to equipment, allow space for service and maintenance.
- D. Identify piping, agent storage cylinders, and control panels with signage in accordance with NFPA 2001.
- E. Provide signage for the pre-discharge bells and strobes. The sign shall say "FIRE. [Agent Surname] RELEASE IMMINENT". The sign shall be permanently affixed to the wall within 12 inches of the pre-discharge strobe.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-15

- F. Provide signage for the discharge strobes. The sign shall say "[Agent Surname] DISCHARGE". The sign shall be permanently affixed to the wall within 12 inches of the discharge strobe.
- G. Provide signage on the exterior of the protected space at each entrance. The sign shall say "THIS SPACE IS PROTECTED BY A CLEAN AGENT FIRE EXTINGUISHING SYSTEM. DO NOT ENTER WITHOUT AUTHORIZATION DURING OR AFTER DISCHARGE. THE RED STROBE INDICATES SYSTEM DISCHARGE." The sign shall be permanently affixed to the wall adjacent to the door.
- H. Provide signage adjacent to each manual activation station. The sign shall say "ACTUATION OF THIS DEVICE WILL CAUSE FIRE SUPPRESSION GAS TO DISCHARGE. BEFORE ACTUATING, ENSURE THAT PERSONNEL ARE CLEAR OF THE AREA." The sign shall be permanently affixed to the wall within 12 inches of the station.
- I. Firestopping shall be provided for all penetrations of fire resistance rated construction. Firestopping shall comply with Section 07 84 00, FIRESTOPPING.
- J. Repairs: Repair damage to the building or equipment resulting from the installation of the clean agent fire extinguishing system by the installer at no additional expense to the Government.
- K. Supervise clean agent control panel for alarm, supervisory, and trouble signals by the building fire alarm system in accordance with Section 28 31 00, FIRE DETECTION AND ALARM.
- L. Where duct detectors are provided within computer room air conditioning units, addressable interface modules shall be used to monitor the activation of the duct detector as a supervisory signal on the clean agent control unit.
- M. Control emergency power off with addressable interface modules.

3.2 SEQUENCE OF OPERATIONS

- A. The clean agent extinguishing fire extinguishing system shall operate as follows:
 - 1. Activation of any single smoke detector shall:
 - a. Energize an alarm LED lamp on the activated detector and clean agent control panel.
 - b. Transmit an alarm signal to the building's fire alarm system.
 - 2. Activation of a second smoke detector shall:
 - a. Energize an alarm LED lamp on the activator detector.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-15

- b. Activate pre-discharge bell notification appliance and pre-discharge strobe notification appliance.
 - c. Shut down power to electronic equipment within the protected space, close dampers, release door hold open devices, and shut down air handling units serving the protected space.
 - d. Initiate a programmable 30-second time delay (agent release) sequence.
3. Activation of a manual activation station shall:
- a. Energize an alarm LED lamp on the clean agent control panel.
 - b. Activate pre-discharge bell notification appliance and pre-discharge strobe notification appliance.
 - c. Shut down power to electronic equipment within the protected space, close dampers, release door hold open devices, and shut down air handling units serving the protected space.
 - d. Transmit an alarm signal to the building's fire alarm system.
 - e. Initiate a programmable 20-second time delay (agent release) sequence.
4. Activation of the abort switch shall:
- a. Cease the time delay. Once the abort switch is released, the time delay countdown shall resume from where it ceased. The time delay shall not reset.
 - b. Transmit a trouble signal to the building's fire alarm system.
5. Upon completion of the time delay, the system shall:
- a. De-energize the pre-discharge bell and pre-discharge strobe notification appliance.
 - b. Activate a discharge strobe notification appliance inside and outside of the protected area.
 - c. Energize valve actuator for agent cylinders releasing gaseous agent into the protected area.
6. Activation of the low agent tank pressure switch and maintenance lock-out switch shall:
- a. Energize a supervisory LED lamp on the clean agent control panel.
 - b. Transmit a supervisory alarm signal to the building's fire alarm system.
7. Presence of any fault, bypass function, or removal of the electric valve actuator shall:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-15

- a. Energize a trouble LED lamp on the clean agent control panel.
- b. Transmit a trouble signal to the building's fire alarm system.
- 8. Activation of duct detector within a computer room air condition unit shall energize a supervisory signal LED lamp on the clean agent control panel.

3.3 INSPECTION AND TEST

- A. Room Enclosure Test: A room pressurization test shall be conducted for the protected space. The testing shall be done in accordance with NFPA 2001 Annex C. The contractor shall be responsible for sealing the enclosure to ensure the success of the room pressurization test. The test shall be deemed successful if the tested leakage rate is less than or equal to the leakage rate assumed in the calculations.
- B. Pressure Test: Pneumatically pressure test piping in a closed circuit in accordance with NFPA 2001.
- C. Flow Test: Subject system to a flow test utilizing nitrogen to verify that flow is continuous and that the piping and nozzles are unobstructed.
- D. Preliminary Testing: System function operation test system as specified in NFPA 2001 and NFPA 72, in the presence of the COR or his designated representative.
- E. Final Inspection and Testing: Subject system to tests in accordance with NFPA 2001 and NFPA 72, and when all necessary corrections have been accomplished, advise COR to schedule a final inspection and test. Connection to the fire alarm system shall have been in service for at least ten days prior to the final inspection, with adjustments made to prevent false alarms. Furnish all instruments, labor and materials required for the tests and provide the services of the installation foreman or other competent representative of the installer to perform the tests. Correct deficiencies and retest system as necessary, prior to the final acceptance. Include the operation of all features of the systems under normal operations in test.

3.4 TRAINING

- A. The manufacturer's authorized representative shall provide instruction and training to the VA on the dates requested by the COR as follows:

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-15

1. Six 1-hour sessions to employees working in protected area, engineering staff, security police and VA Fire Department personnel where there is a VA Fire Department present on site for simple operation of the system. Two sessions at the start of installation, 2 sessions at the completion of installation and 2 sessions 3 months after the completion of installation.
 2. Four 2-hour sessions to engineering staff for detailed operation of the system. Two sessions at the completion of installation and 2 sessions 3 months after the completion of installation.
 3. Three 8-hour sessions to electrical technicians for maintaining, programming, modifying, and repairing the system at the completion of installation and one 8-hour refresher session 3 months after the completion of installation.
- B. Each initial training session shall be videotaped.

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DIVISION 22

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

SECTION 22 05 11
COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements of this Section will apply to all sections of Division 22.

B. Definitions:

1. Exposed: Piping and equipment exposed to view in finished rooms.
2. Exterior: Piping and equipment exposed to weather be it temperature, humidity, precipitation, wind or solar radiation.

C. Abbreviations/Acronyms:

1. ABS: Acrylonitrile Butadiene Styrene
2. AC: Alternating Current
3. ACR: Air Conditioning and Refrigeration
4. A/E: Architect/Engineer
5. AFF: Above Finish Floor
6. AFG: Above Finish Grade
7. AI: Analog Input
8. AISI: American Iron and Steel Institute
9. AO: Analog Output
10. ASHRAE: American Society of Heating Refrigeration, Air Conditioning Engineers
11. ASJ: All Service Jacket
12. ASME: American Society of Mechanical Engineers
13. ASPE: American Society of Plumbing Engineers
14. AWG: American Wire Gauge
15. BACnet: Building Automation and Control Network
16. BAg: Silver-Copper-Zinc Brazing Alloy
17. BAS: Building Automation System
18. BCuP: Silver-Copper-Phosphorus Brazing Alloy
19. bhp: Brake Horsepower
20. Btu: British Thermal Unit
21. Btu/h: British Thermal Unit per Hour
22. BSG: Borosilicate Glass Pipe
23. C: Celsius
24. CA: Compressed Air

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

- 25. CD: Compact Disk
- 26. CDA: Copper Development Association
- 27. CGA: Compressed Gas Association
- 28. CFM: Cubic Feet per Minute
- 29. CI: Cast Iron
- 30. CLR: Color
- 31. CO: Contracting Officer
- 32. COR: Contracting Officer's Representative
- 33. CPVC: Chlorinated Polyvinyl Chloride
- 34. CR: Chloroprene
- 35. CRS: Corrosion Resistant Steel
- 36. CWP: Cold Working Pressure
- 37. CxA: Commissioning Agent
- 38. dB: Decibels
- 39. db(A): Decibels (A weighted)
- 40. DCW: Domestic Cold Water
- 41. DDC: Direct Digital Control
- 42. DFU: Drainage Fixture Units
- 43. DHW: Domestic Hot Water
- 44. DHWR: Domestic Hot Water Return
- 45. DHWS: Domestic Hot Water Supply
- 46. DI: Digital Input
- 47. DI: Deionized Water
- 48. DISS: Diameter Index Safety System
- 49. DN: Diameter Nominal
- 50. DO: Digital Output
- 51. DOE: Department of Energy
- 52. DVD: Digital Video Disc
- 53. DWG: Drawing
- 54. DWH: Domestic Water Heater
- 55. DWS: Domestic Water Supply
- 56. DWV: Drainage, Waste and Vent
- 57. ECC: Engineering Control Center
- 58. EL: Elevation
- 59. EMCS: Energy Monitoring and Control System
- 60. EPA: Environmental Protection Agency

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

- 61. EPACT: Energy Policy Act
- 62. EPDM: Ethylene Propylene Diene Monomer
- 63. EPT: Ethylene Propylene Terpolymer
- 64. ETO: Ethylene Oxide
- 65. F: Fahrenheit
- 66. FAR: Federal Acquisition Regulations
- 67. FD: Floor Drain
- 68. FDC: Fire Department (Hose) Connection
- 69. FED: Federal
- 70. FG: Fiberglass
- 71. FNPT: Female National Pipe Thread
- 72. FOR: Fuel Oil Return
- 73. FOS: Fuel Oil Supply
- 74. FOV: Fuel Oil Vent
- 75. FPM: Fluoroelastomer Polymer
- 76. FSK: Foil-Scrim-Kraft Facing
- 77. FSS: VA Construction & Facilities Management, Facility Standards
Service
- 78. FU: Fixture Units
- 79. GAL: Gallon
- 80. GCO: Grade Cleanouts
- 81. GPD: Gallons per Day
- 82. GPH: Gallons per Hour
- 83. GPM: Gallons per Minute
- 84. HDPE: High Density Polyethylene
- 85. HEFP: Healthcare Environment and Facilities Program (replacement for
OCAMES)
- 86. HEX: Heat Exchanger
- 87. Hg: Mercury
- 88. HOA: Hands-Off-Automatic
- 89. HP: Horsepower
- 90. HVE: High Volume Evacuation
- 91. Hz: Hertz
- 92. ID: Inside Diameter
- 93. IE: Invert Elevation
- 94. INV: Invert

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

- 95. IPC: International Plumbing Code
- 96. IPS: Iron Pipe Size
- 97. IW: Indirect Waste
- 98. IWH: Instantaneous Water Heater
- 99. Kg: Kilogram
- 100. kPa: Kilopascal
- 101. KW: Kilowatt
- 102. KWH: Kilowatt Hour
- 103. lb: Pound
- 104. lbs/hr: Pounds per Hour
- 105. LNG: Liquid Natural Gas
- 106. L/min: Liters per Minute
- 107. LOX: Liquid Oxygen
- 108. L/s: Liters per Second
- 109. m: Meter
- 110. MA: Medical Air
- 111. MAWP: Maximum Allowable Working Pressure
- 112. MAX: Maximum
- 113. MBH: 1000 Btu per Hour
- 114. MED: Medical
- 115. MER: Mechanical Equipment Room
- 116. MFG: Manufacturer
- 117. mg: Milligram
- 118. mg/L: Milligrams per Liter
- 119. ml: Milliliter
- 120. mm: Millimeter
- 121. MIN: Minimum
- 122. MV: Medical Vacuum
- 123. N2: Nitrogen
- 124. N2O: Nitrogen Oxide
- 125. NC: Normally Closed
- 126. NF: Oil Free Dry (Nitrogen)
- 127. NG: Natural Gas
- 128. NIC: Not in Contract
- 129. NO: Normally Open
- 130. NOM: Nominal

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

- 131. NPTF: National Pipe Thread Female
- 132. NPS: Nominal Pipe Size
- 133. NPT: Nominal Pipe Thread
- 134. NTS: Not to Scale
- 135. O2: Oxygen
- 136. OC: On Center
- 137. OD: Outside Diameter
- 138. OSD: Open Sight Drain
- 139. OS&Y: Outside Stem and Yoke
- 140. PA: Pascal
- 141. PBPU: Prefabricated Bedside Patient Units
- 142. PD: Pressure Drop or Difference
- 143. PDI: Plumbing and Drainage Institute
- 144. PH: Power of Hydrogen
- 145. PID: Proportional-Integral-Differential
- 146. PLC: Programmable Logic Controllers
- 147. PP: Polypropylene
- 148. ppb: Parts per Billion
- 149. ppm: Parts per Million
- 150. PSI: Pounds per Square Inch
- 151. PSIA: Pounds per Square Inch Atmosphere
- 152. PSIG: Pounds per Square Inch Gauge
- 153. PTFE: Polytetrafluoroethylene
- 154. PVC: Polyvinyl Chloride
- 155. PVDF: Polyvinylidene Fluoride
- 156. RAD: Radians
- 157. RO: Reverse Osmosis
- 158. RPM: Revolutions Per Minute
- 159. RTD: Resistance Temperature Detectors
- 160. RTRP: Reinforced Thermosetting Resin Pipe
- 161. SAN: Sanitary Sewer
- 162. SCFM: Standard Cubic Feet per Minute
- 163. SDI: Silt Density Index
- 164. SMACNA: Sheet Metal and Air Conditioning Contractors National Association

165. SPEC: Specification
Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

- 166. SPS: Sterile Processing Services
- 167. SQFT/SF: Square Feet
- 168. SS: Stainless Steel
- 169. STD: Standard
- 170. SUS: Saybolt Universal Second
- 171. SWP: Steam Working Pressure
- 172. TD: Temperature Difference
- 173. TDH: Total Dynamic Head
- 174. TEFC: Totally Enclosed Fan-Cooled
- 175. TEMP: Temperature
- 176. TFE: Tetrafluoroethylene
- 177. THERM: 100,000 Btu
- 178. THHN: Thermoplastic High-Heat Resistant Nylon Coated Wire
- 179. THWN: Thermoplastic Heat & Water Resistant Nylon Coated Wire
- 180. TIL: Technical Information Library
<http://www.cfm.va.gov/til/index.asp>
- 181. T/P: Temperature and Pressure
- 182. TYP: Typical
- 183. USDA: U.S. Department of Agriculture
- 184. V: Vent
- 185. V: Volt
- 186. VA: Veterans Administration
- 187. VA CFM: VA Construction & Facilities Management
- 188. VA CFM CSS: VA Construction & Facilities Management, Consulting
Support Service
- 189. VAC: Vacuum
- 190. VAC: Voltage in Alternating Current
- 191. VAMC: Veterans Administration Medical Center
- 192. VHA OCAMES: This has been replaced by HEFP.
- 193. VSD: Variable Speed Drive
- 194. VTR: Vent through Roof
- 195. W: Waste
- 196. WAGD: Waste Anesthesia Gas Disposal
- 197. WC: Water Closet
- 198. WG: Water Gauge
- 199. WOG: Water, Oil, Gas

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

200. WPD: Water Pressure Drop

201. WSFU: Water Supply Fixture Units

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.
- D. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.
- E. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
- F. Section 02 82 11, TRADITIONAL ASBESTOS ABATEMENT.
- G. Section 05 50 00, METAL FABRICATIONS.
- H. Section 07 60 00, FLASHING AND SHEET METAL: Flashing for Wall and Roof Penetrations.
- I. Section 07 84 00, FIRESTOPPING.
- J. Section 07 92 00, JOINT SEALANTS.
- K. Section 09 91 00, PAINTING.
- L. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
- M. Section 22 07 11, PLUMBING INSULATION.
- N. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below will form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.
- B. American Society of Mechanical Engineers (ASME):
 - B31.1-2013.....Power Piping
 - ASME Boiler and Pressure Vessel Code -
 - BPVC Section IX-2019.... Welding, Brazing, and Fusing Qualifications
- C. American Society for Testing and Materials (ASTM):
 - A36/A36M-2019.....Standard Specification for Carbon Structural Steel
 - A575-96(2013)e1.....Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades
 - E84-2013a.....Standard Test Method for Surface Burning Characteristics of Building Materials

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

E119-2012a.....Standard Test Methods for Fire Tests of
Building Construction and Materials

D. International Code Council, (ICC):

IBC-2018.....International Building Code

IPC-2018.....International Plumbing Code

E. Manufacturers Standardization Society (MSS) of the Valve and Fittings
Industry, Inc:

SP-58-2018.....Pipe Hangers and Supports - Materials, Design,
Manufacture, Selection, Application and
Installation

F. Military Specifications (MIL):

P-21035B.....Paint High Zinc Dust Content, Galvanizing
Repair (Metric)

G. National Electrical Manufacturers Association (NEMA):

MG 1-2016.....Motors and Generators

H. National Fire Protection Association (NFPA):

51B-2019.....Standard for Fire Prevention During Welding,
Cutting and Other Hot Work

54-2018.....National Fuel Gas Code

70-2020.....National Electrical Code (NEC)

99-2018.....Healthcare Facilities Code

I. NSF International (NSF):

5-2019.....Water Heaters, Hot Water Supply Boilers, and
Heat Recovery Equipment

14-2019.....Plastic Piping System Components and Related
Materials

61-2019.....Drinking Water System Components - Health
Effects

372-2016.....Drinking Water System Components - Lead Content

J. Department of Veterans Affairs (VA):

PG-18-102014 (R18).....Plumbing Design Manual

PG-18-13-2017 (R18).....Barrier Free Design Guide

1.4 SUBMITTALS

A. Submittals, including number of required copies, will be submitted in
accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and
SAMPLES.

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

- B. Information and material submitted under this section will be marked "SUBMITTED UNDER SECTION 22 05 11, COMMON WORK RESULTS FOR PLUMBING", with applicable paragraph identification.
- C. If the project is phased, contractors will submit complete phasing plan/schedule with manpower levels prior to commencing work. The phasing plan will be detailed enough to provide milestones in the process that can be verified.
- D. Contractor will make all necessary field measurements and investigations to assure that the equipment and assemblies will meet contract requirements, and all equipment that requires regular maintenance, calibration, etc are accessible from the floor or permanent work platform. It is the Contractor's responsibility to ensure all submittals meet the VA specifications and requirements and it is assumed by the VA that all submittals do meet the VA specifications unless the Contractor has requested a variance in writing and approved by COR prior to the submittal. If at any time during the project it is found that any item does not meet the VA specifications and there was no variance approval the Contractor will correct at no additional cost or time to the Government even if a submittal was approved.
- E. If equipment is submitted which differs in arrangement from that shown, provide documentation proving equivalent performance, design standards and drawings that show the rearrangement of all associated systems. Additionally, any impacts on ancillary equipment or services such as foundations, piping, and electrical will be the Contractor's responsibility to design, supply, and install at no additional cost or time to the Government. VA approval will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract.
- F. Prior to submitting shop drawings for approval, Contractor will certify in writing that manufacturers of all major items of equipment have each reviewed drawings and specifications, and have jointly coordinated and properly integrated their equipment and controls to provide a complete and efficient installation.
- G. Submittals and shop drawings for interdependent items, containing applicable descriptive information, will be furnished together and

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

complete in a group. Coordinate and properly integrate materials and equipment in each group to provide a completely compatible and efficient installation. Final review and approvals will be made only by groups.

H. Manufacturer's Literature and Data including: Manufacturer's literature will be submitted under the pertinent section rather than under this section.

1. Electric motor data and variable speed drive data will be submitted with the driven equipment.
2. Equipment and materials identification.
3. Firestopping materials.
4. Hangers, inserts, supports and bracing. Provide load calculations for variable spring and constant support hangers.
5. Wall, floor, and ceiling plates.

I. Coordination/Shop Drawings:

1. Submit complete consolidated and coordinated shop drawings for all new systems, and for existing systems that are in the same areas.
2. The coordination/shop drawings will include plan views, elevations and sections of all systems and will be on a scale of not less than 3/8-inch equal to 1 foot. Clearly identify and dimension the proposed locations of the principal items of equipment. The drawings will clearly show locations and adequate clearance for all equipment, piping, valves, control panels and other items. Show the access means for all items requiring access for operations and maintenance. Provide detailed coordination/shop drawings of all piping and duct systems. The drawings should include all lockout/tagout points for all energy/hazard sources for each piece of equipment. Coordinate lockout/tagout procedures and practices with local VA requirements.
3. Do not install equipment foundations, equipment or piping until coordination/shop drawings have been approved.
4. In addition, for plumbing systems, provide details of the following:
 - a. Mechanical equipment rooms.
 - b. Hangers, inserts, supports, and bracing.
 - c. Pipe sleeves.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

- d. Duct or equipment penetrations of floors, walls, ceilings, or roofs.
- J. Rigging Plan: Provide documentation of the capacity and weight of the rigging and equipment intended to be used. The plan will include the path of travel of the load, the staging area and intended access, and qualifications of the operator and signal person.
- K. Plumbing Maintenance Data and Operating Instructions:
1. Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS, Article, INSTRUCTIONS, for systems and equipment.
 2. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
 - a. Include complete list indicating all components of the systems.
 - b. Include complete diagrams of the internal wiring for each item of equipment.
 - c. Diagrams will have their terminals identified to facilitate installation, operation and maintenance.
 3. Provide a listing of recommended replacement parts for keeping in stock supply, including sources of supply, for equipment. Include in the listing belts for equipment: Belt manufacturer, model number, size and style, and distinguished whether of multiple belt sets.
- L. Provide copies of approved plumbing equipment submittals to the TAB and Commissioning Subcontractor.
- M. Completed System Readiness Checklist provided by the CxA and completed by the Contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00 COMMISSIONING OF PLUMBING SYSTEMS.
- N. Submit training plans, trainer qualifications and instructor qualifications in accordance with the requirements of Section 22 08 00 COMMISSIONING OF PLUMBING SYSTEMS.

1.5 QUALITY ASSURANCE

- A. Mechanical, electrical, and associated systems will be safe, reliable, efficient, durable, easily and safely operable and maintainable, easily and safely accessible, and in compliance with applicable codes as specified. The systems will be comprised of high quality institutional-

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

class and industrial-class products of manufacturers that are experienced specialists in the required product lines. All construction firms and personnel will be experienced and qualified specialists in industrial and institutional plumbing.

B. Products Criteria:

1. **Standard Products:** Material and equipment will be the standard products of a manufacturer regularly engaged in the manufacture, supply and servicing of the specified products for at least 5 years. However, digital electronics devices, software and systems such as controls, instruments, computer work station, will be the current generation of technology and basic design that has a proven satisfactory service record of at least 5 years.
2. **Equipment Service:** There will be permanent service organizations, authorized and trained by manufacturers of the equipment supplied, located within 160 km (100 miles) of the project. These organizations will come to the site and provide acceptable service to restore operations within 4 hours of receipt of notification by phone, e-mail or fax in event of an emergency, such as the shut-down of equipment; or within 24 hours in a non-emergency. Names, mail and e-mail addresses and phone numbers of service organizations providing service under these conditions for (as applicable to the project): pumps, compressors, water heaters, critical instrumentation, computer workstation and programming will be submitted for project record and inserted into the operations and maintenance manual.
3. All items furnished will be free from defects that would adversely affect the performance, maintainability and appearance of individual components and overall assembly.
4. The products and execution of work specified in Division 22 will conform to the referenced codes and standards as required by the specifications. Local codes and amendments enforced by the local code official will be enforced, if required by local authorities such as the natural gas supplier. If the local codes are more stringent, then the local code will apply. Any conflicts will be brought to the attention of the Contracting Officers Representative (COR).

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

5. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units will be of the same manufacturer and model number, or if different models are required they will be of the same manufacturer and identical to the greatest extent possible (i.e., same model series).
 6. Assembled Units: Performance and warranty of all components that make up an assembled unit will be the responsibility of the manufacturer of the completed assembly.
 7. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark will be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped or otherwise permanently marked on each item of equipment.
 8. Asbestos products or equipment or materials containing asbestos is prohibited.
 9. Bio-Based Materials: For products designated by the USDA's bio-based Bio-Preferred Program, provide products that meet or exceed USDA recommendations for bio-based content, so long as products meet all performance requirements in this specifications section. For more information regarding the product categories covered by the Bio-Preferred Program, visit <http://www.biopREFERRED.gov>.
- C. Welding: Before any welding is performed, Contractor will submit a certificate certifying that welders comply with the following requirements:
1. Qualify welding processes and operators for piping according to ASME BPVC, Section IX, "Welding and Brazing Qualifications". Provide proof of current certification to CO.
 2. Comply with provisions of ASME B31 series "Code for Pressure Piping".
 3. Certify that each welder and welding operator has passed American Welding Society (AWS) qualification tests for the welding processes involved, and that certification is current.
 4. All welds will be stamped according to the provisions of the AWS or ASME as required herein and by the association code.
- D. Manufacturer's Recommendations: Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

these recommendations will be furnished to the COR prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

E. Execution (Installation, Construction) Quality:

1. All items will be applied and installed in accordance with manufacturer's written instructions. Conflicts between the manufacturer's instructions and the contract documents will be referred to the COR for resolution. Printed copies or electronic files of manufacturer's installation instructions will be provided to the COR at least 10 working days prior to commencing installation of any item.
2. All items that require access, such as for operating, cleaning, servicing, maintenance, and calibration, will be easily and safely accessible by persons standing at floor level, or standing on permanent platforms, without the use of portable ladders. Examples of these items include but are not limited to: all types of valves, filters and strainers, transmitters, and control devices. Prior to commencing installation work, refer conflicts between this requirement and contract documents to COR for resolution. Failure of the Contractor to resolve or call attention to any discrepancies or deficiencies to the COR will result in the Contractor correcting at no additional cost or time to the Government.
3. Complete layout drawings will be required by Paragraph, SUBMITTALS. Construction work will not start on any system until the layout drawings have been approved by VA.
4. Installer Qualifications: Installer will be licensed and will provide evidence of the successful completion of at least five projects of equal or greater size and complexity. Provide tradesmen skilled in the appropriate trade.
5. Workmanship/craftsmanship will be of the highest quality and standards. The VA reserves the right to reject any work based on poor quality of workmanship this work will be removed and done again at no additional cost or time to the Government.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

- F. Upon request by Government, provide lists of previous installations for selected items of equipment. Include contact persons who will serve as references, with current telephone numbers and e-mail addresses.
- G. Guaranty: Warranty of Construction, FAR clause 52.246-21.
- H. Plumbing Systems: IPC, International Plumbing Code. Unless otherwise required herein, perform plumbing work in accordance with the latest version of the IPC. For IPC codes referenced in the contract documents, advisory provisions will be considered mandatory, the word "should" will be interpreted as "will". Reference to the "code official" or "owner" will be interpreted to mean the COR.
- I. Cleanliness of Piping and Equipment Systems:
1. Care will be exercised in the storage and handling of equipment and piping material to be incorporated in the work. Debris arising from cutting, threading and welding of piping will be removed.
 2. Piping systems will be flushed, blown or pigged as necessary to deliver clean systems.
 3. The interior of all tanks will be cleaned prior to delivery and beneficial use by the Government. All piping will be tested in accordance with the specifications and the International Plumbing Code (IPC). All filters, strainers, fixture faucets will be flushed of debris prior to final acceptance.
 4. Contractor will be fully responsible for all costs, damage, and delay arising from failure to provide clean systems.

1.6 DELIVERY, STORAGE AND HANDLING

A. Protection of Equipment:

1. Equipment and material placed on the job site will remain in the custody of the Contractor until phased acceptance, whether or not the Government has reimbursed the Contractor for the equipment and material. The Contractor is solely responsible for the protection of such equipment and material against any damage or theft.
2. Damaged equipment will be replaced with an identical unit as determined and directed by the COR. Such replacement will be at no additional cost or additional time to the Government.
3. Interiors of new equipment and piping systems will be protected against entry of foreign matter. Both inside and outside will be cleaned before painting or placing equipment in operation.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

4. Existing equipment and piping being worked on by the Contractor will be under the custody and responsibility of the Contractor and will be protected as required for new work.
5. Protect plastic piping and tanks from ultraviolet light (sunlight) while in pre-construction. Plastic piping and tanks will not be installed exposed to sunlight without metal jacketing to block ultraviolet rays.

1.7 AS-BUILT DOCUMENTATION

- A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- B. Submit operation and maintenance data updated to include submittal review comments, VA approved substitutions and construction revisions will be in electronic version on CD or DVD inserted into a three-ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation will be included in the operation and maintenance manual. The operations and maintenance manual will include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices will be included. A List of recommended spare parts (manufacturer, model number, and quantity) will be furnished. Information explaining any special knowledge or tools the owner will be required to employ will be inserted into the As-Built documentation.
- C. The installing Contractor will maintain as-built drawings of each completed phase for verification; and, will provide the complete set at the time of final systems certification testing. Should the installing Contractor engage the testing company to provide as-built or any portion thereof, it will not be deemed a conflict of interest or breach of the 'third party testing company' requirement. Provide record drawings as follows:
 1. Red-lined, hand-marked drawings are to be provided, with one paper copy and a scanned PDF version of the hand-marked drawings provided on CD or DVD.
 2. As-built drawings are to be provided, with a copy of them on AutoCAD version 2010 provided on CD or DVD. The CAD drawings will use

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

multiple line layers with a separate individual layer for each system.

- D. The as-built drawings will indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.
- E. Certification documentation will be provided to COR 21 working days prior to submitting the request for final inspection. The documentation will include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results will contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results will include all readings, including but not limited to data on device (make, model and performance characteristics_), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

1.8 JOB CONDITIONS - WORK IN EXISTING BUILDING

- A. Building Operation: Government employees will be continuously operating and managing all facilities, including temporary facilities that serve the VAMC.
- B. Maintenance of Service: Schedule all work to permit continuous service as required by the VAMC.
- C. Steam and Condensate Service Interruptions: Limited steam and condensate service interruptions, as required for interconnections of new and existing systems, will be permitted by the COR during periods when the demands are not critical to the operation of the VAMC. These non-critical periods are limited to between 8 pm and 5 am in the appropriate off-season (if applicable). Provide at least 10 working days advance notice to the COR. The request will include a detailed plan on the proposed shutdown and the intended work to be done along with manpower levels. All equipment and materials must be onsite and verified with plan 5calendarworkdays prior to the shutdown or it will need to be rescheduled.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

- D. Phasing of Work: Comply with all requirements shown on contract documents. Contractor will submit a complete detailed phasing plan/schedule with manpower levels prior to commencing work. The phasing plan will be detailed enough to provide milestones in the process that can be verified.
- E. Building Working Environment: Maintain the architectural and structural integrity of the building and the working environment at all times. Maintain the interior of building at 65 degrees F minimum. Limit the opening of doors, windows or other access openings to brief periods as necessary for rigging purposes. Storm water or ground water leakage is prohibited. Provide daily clean-up of construction and demolition debris on all floor surfaces and on all equipment being operated by VA. Maintain all egress routes and safety systems/devices.
- F. Acceptance of Work for Government Operation: As new equipment, systems and facilities are made available for operation and these items are deemed of beneficial use to the Government, inspections and tests will be performed. Based on the inspections, a list of contract deficiencies will be issued to the Contractor. After correction of deficiencies as necessary for beneficial use, the Contracting Officer will process necessary acceptance and the equipment will then be under the control and operation of Government personnel.
- G. Temporary Facilities: Refer to Paragraph, TEMPORARY PIPING AND EQUIPMENT in this section.

PART 2 - PRODUCTS

2.1 MATERIALS FOR VARIOUS SERVICES

- A. Steel pipe will contain a minimum of 25 percent recycled content.
- B. Material or equipment containing a weighted average of greater than 0.25 percent lead will not be used in any potable water system intended for human consumption and will be certified in accordance with NSF 61 or NSF 372.
- C. In-line devices such as water meters, building valves, check valves, stops, valves, fittings, tanks and backflow preventers will comply with NSF 61 and NSF 372.
- D. End point devices such as drinking fountains, lavatory faucets, kitchen and bar faucets, ice makers supply stops, and end-point control valves

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

used to dispense drinking water must meet requirements of NSF 61 and NSF 372.

2.2 FACTORY-ASSEMBLED PRODUCTS

- A. Standardization of components will be maximized to reduce spare part requirements.
- B. Manufacturers of equipment assemblies that include components made by others will assume complete responsibility for final assembled unit.
 - 1. All components of an assembled unit need not be products of same manufacturer.
 - 2. Constituent parts that are alike will be products of a single manufacturer.
 - 3. Components will be compatible with each other and with the total assembly for intended service.
 - 4. Contractor will guarantee performance of assemblies of components and will repair or replace elements of the assemblies as required to deliver specified performance of the complete assembly at no additional cost or time to the Government.
- C. Components of equipment will bear manufacturer's name and trademark, model number, serial number and performance data on a name plate securely affixed in a conspicuous place, or cast integral with, stamped or otherwise permanently marked upon the components of the equipment.
- D. Major items of equipment, which serve the same function, will be the same make and model.

2.3 COMPATIBILITY OF RELATED EQUIPMENT

- A. Equipment and materials installed will be compatible in all respects with other items being furnished and with existing items so that the result will be a complete and fully operational system that conforms to contract requirements.

2.4 SAFETY GUARDS

- A. Pump shafts and couplings will be fully guarded by a sheet steel guard, covering coupling and shaft but not bearings. Material will be minimum 16-gauge sheet steel; ends will be braked and drilled and attached to pump base with minimum of four 1/4 inch bolts. Reinforce guard as necessary to prevent side play forcing guard onto couplings.
- B. All Equipment will have moving parts protected from personal injury.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

2.5 LIFTING ATTACHMENTS

- A. Equipment will be provided with suitable lifting attachments to enable equipment to be lifted in its normal position. Lifting attachments will withstand any handling conditions that might be encountered, without bending or distortion of shape, such as rapid lowering and braking of load.

2.6 ELECTRIC MOTORS, MOTOR CONTROL, CONTROL WIRING

- A. All material and equipment furnished and installation methods used will conform to the requirements of Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT; Section 26 29 11, MOTOR CONTROLLERS; and, Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES. All electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems will be provided. Premium efficient motors will be provided. Unless otherwise specified for a particular application, electric motors will have the following requirements.

B. Special Requirements:

1. Where motor power requirements of equipment furnished deviate from power shown on plans, provide electrical service designed under the requirements of NFPA 70 at no additional cost or time to the Government.
2. Assemblies of motors, starters, and controls and interlocks on factory assembled and wired devices will be in accordance with the requirements of this specification.
3. Wire and cable materials specified in the electrical division of the specifications will be modified as follows:
 - a. Wiring material located where temperatures can exceed 160° F will be stranded copper with Teflon FEP insulation with jacket. This includes wiring on the boilers and water heaters.
 - b. Other wiring at boilers and water heaters, and to control panels, will be NFPA 70 designation THWN.
 - c. Shielded conductors or wiring in separate conduits for all instrumentation and control systems will be provided where recommended by manufacturer of equipment.
4. Motor sizes will be selected so that the motors do not operate into the service factor at maximum required loads on the driven

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

- equipment. Motors on pumps will be sized for non-overloading at all points on the pump performance curves.
5. Motors utilized with variable frequency drives will be rated "inverter-ready" per NEMA Standard, MG1.
- C. Motor Efficiency and Power Factor: All motors, when specified as "high efficiency or Premium Efficiency" by the project specifications on driven equipment, will conform to efficiency and power factor requirements in Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT, with no consideration of annual service hours. Motor manufacturers generally define these efficiency requirements as "NEMA premium efficient" and the requirements generally exceed those of the Energy Policy Act (EPACT), revised 2005. Motors not specified as "high efficiency or premium efficient" will comply with EPACT.
- D. Single-phase Motors: Capacitor-start type for hard starting applications. Motors for centrifugal pumps may be split phase or permanent split capacitor (PSC).
- E. Poly-phase Motors: NEMA Design B, Squirrel cage, induction type. Each two-speed motor will have two separate windings. A time delay (20 seconds minimum) relay will be provided for switching from high to low speed.
- F. Rating: Rating will be continuous duty at 100 percent capacity in an ambient temperature of 104° F; minimum horsepower as shown on drawings; maximum horsepower in normal operation will not exceed nameplate rating without service factor.
- G. Insulation Resistance: Not less than one-half meg-ohm between stator conductors and frame will be measured at the time of final inspection.

2.7 VARIABLE SPEED MOTOR CONTROLLERS (NOT USED)

2.8 EQUIPMENT AND MATERIALS IDENTIFICATION

- A. Use symbols, nomenclature and equipment numbers specified, shown in the drawings, or shown in the maintenance manuals. Coordinate equipment and valve identification with local VAMC shops. In addition, provide bar code identification nameplate for all equipment which will allow the equipment identification code to be scanned into the system for maintenance and inventory tracking. Identification for piping is specified in Section 09 91 00, PAINTING.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

- B. Interior (Indoor) Equipment: Engraved nameplates, with letters not less than 3/16 inch high of brass with black-filled letters, or rigid black plastic with white letters specified in Section 09 91 00, PAINTING will be permanently fastened to the equipment. Unit components such as water heaters, tanks, coils, filters, etc. will be identified.
- C. Exterior (Outdoor) Equipment: Brass nameplates, with engraved black filled letters, not less than 3/16 inch high riveted or bolted to the equipment.
- D. Control Items: All temperature, pressure, and controllers will be labeled and the component's function identified. Identify and label each item as they appear on the control diagrams.
- E. Valve Tags and Lists:
1. Plumbing: All valves will be provided with valve tags and listed on a valve list (Fixture stops not included).
 2. Valve tags: Engraved black filled numbers and letters not less than 1/2 inch high for number designation, and not less than 1/4 inch for service designation on 19 gauge, 1-1/2 inches round brass disc, attached with brass "S" hook or brass chain.
 3. Valve lists: Valve lists will be created using a word processing program and printed on plastic coated cards. The plastic-coated valve list card(s), sized 8-1/2 inches by 11 inches will show valve tag number, valve function and area of control for each service or system. The valve list will be in a punched 3-ring binder notebook. An additional copy of the valve list will be mounted in picture frames for mounting to a wall. COR will instruct Contractor where frames will be mounted.
 4. A detailed plan for each floor of the building indicating the location and valve number for each valve will be provided in the 3-ring binder notebook. Each valve location will be identified with a color-coded sticker or thumb tack in ceiling or access door.

2.9 FIRESTOPPING

- A. Section 07 84 00, FIRESTOPPING specifies an effective barrier against the spread of fire, smoke and gases where penetrations occur for piping. Refer to Section 22 07 11, PLUMBING INSULATION, for pipe insulation.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

2.10 GALVANIZED REPAIR COMPOUND

- A. Mil. Spec. DOD-P-21035B, paint.

2.11 PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS

- A. In lieu of the paragraph which follows, suspended equipment support and restraints may be designed and installed in accordance with the International Building Code (IBCSubmittals based on the International Building Code (IBCrequirements, or the following paragraphs of this Section will be stamped and signed by a professional engineer registered in the state where the project is located. The Support system of suspended equipment over 500 pounds will be submitted for approval of the COR in all cases. See the above specifications for lateral force design requirements.
- B. Type Numbers Specified: For materials, design, manufacture, selection, application, and installation refer to MSS SP-58. Refer to Section 05 50 00, METAL FABRICATIONS, for miscellaneous metal support materials and prime coat painting.
- C. For Attachment to Concrete Construction:
1. Concrete insert: Type 18, MSS SP-58.
 2. Self-drilling expansion shields and machine bolt expansion anchors: Permitted in concrete not less than 4 inches thick when approved by the COR for each job condition.
 3. Power-driven fasteners: Permitted in existing concrete or masonry not less than 4 inches) thick when approved by the COR for each job condition.
- D. For Attachment to Steel Construction: MSS SP-58.
1. Welded attachment: Type 22.
 2. Beam clamps: Types 20, 21, 28 or 29. Type 23 C-clamp may be used for individual copper tubing up to 7/8 inch outside diameter.
- E. Attachment to Metal Pan or Deck: As required for materials specified in Section 05 31 00, STEEL DECKING. Section 05 36 00, COMPOSITE METAL DECKING.
- F. For Attachment to Wood Construction: Wood screws or lag bolts.
- G. Hanger Rods: Hot-rolled steel, ASTM A36/A36M or ASTM A575 for allowable load listed in MSS SP-58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turn-buckles will provide

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

1-1/2 inches) minimum of adjustment and incorporate locknuts.

All-thread rods are acceptable.

- H. Multiple (Trapeze) Hangers: Galvanized, cold formed, lipped steel channel horizontal member, not less than 1-5/8 inches by 1-5/8 inches, No. 12 gauge, designed to accept special spring held, hardened steel nuts.

1. Allowable hanger load: Manufacturers rating less 200 pounds.
2. Guide individual pipes on the horizontal member of every other trapeze hanger with 1/4 inch U-bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 1/2 inch galvanized steel bands, or insulated calcium silicate shield for insulated piping at each hanger.

- I. Pipe Hangers and Supports: (MSS SP-58), use hangers sized to encircle insulation on insulated piping. Refer to Section 22 07 11, PLUMBING INSULATION for insulation thickness. To protect insulation, provide Type 39 saddles for roller type supports or insulated calcium silicate shields. Provide Type 40 insulation shield or insulated calcium silicate shield at all other types of supports and hangers including those for insulated piping.

1. General Types (MSS SP-58):

- a. Standard clevis hanger: Type 1; provide locknut.
- b. Riser clamps: Type 8.
- c. Wall brackets: Types 31, 32 or 33.
- d. Roller supports: Type 41, 43, 44 and 46.
- e. Saddle support: Type 36, 37 or 38.
- f. Turnbuckle: Types 13 or 15.
- g. U-bolt clamp: Type 24.
- h. Copper Tube:

- 1) Hangers, clamps and other support material in contact with tubing will be painted with copper colored epoxy paint, copper-coated, plastic coated or taped with isolation tape to prevent electrolysis.
- 2) For vertical runs use epoxy painted, copper-coated or plastic coated riser clamps.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

- 3) For supporting tube to strut: Provide epoxy painted pipe straps for copper tube or plastic inserted vibration isolation clamps.
- 4) Insulated Lines: Provide pre-insulated calcium silicate shields sized for copper tube.
- i. Supports for plastic or glass piping: As recommended by the pipe manufacturer with black rubber tape extending 1 inch beyond steel support or clamp. Spring Supports (Expansion and contraction of vertical piping):
 - 1) Movement up to 3/4 inch: Type 51 or 52 variable spring unit with integral turn buckle and load indicator.
 - 2) Movement more than 3/4 inch: Type 54 or 55 constant support unit with integral adjusting nut, turn buckle and travel position indicator.
- j. Spring hangers are required on all plumbing system pumps one horsepower and greater.
2. Plumbing Piping (Other Than General Types):
 - a. Horizontal piping: Type 1, 5, 7, 9, and 10.
 - b. Chrome plated piping: Chrome plated supports.
 - c. Hangers and supports in pipe chase: Prefabricated system ABS self-extinguishing material, not subject to electrolytic action, to hold piping, prevent vibration and compensate for all static and operational conditions.
 - d. Blocking, stays and bracing: Angle iron or preformed metal channel shapes, 18 gauge minimum.
- J. Pre-insulated Calcium Silicate Shields:
 1. Provide 360-degree water resistant high density 140 psig compressive strength calcium silicate shields encased in galvanized metal.
 2. Pre-insulated calcium silicate shields to be installed at the point of support during erection.
 3. Shield thickness will match the pipe insulation.
 4. The type of shield is selected by the temperature of the pipe, the load it must carry, and the type of support it will be used with.
 - a. Shields for supporting cold water will have insulation that extends a minimum of 1 inch past the sheet metal.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

- b. The insulated calcium silicate shield will support the maximum allowable water filled span as indicated in MSS SP-58. To support the load, the shields will have one or more of the following features: structural inserts 600 psig compressive strength, an extra bottom metal shield, or formed structural steel (ASTM A36/A36M) wear plates welded to the bottom sheet metal jacket.
- 5. Shields may be used on steel clevis hanger type supports, trapeze hangers, roller supports or flat surfaces.
- K. Seismic Restraint of Piping: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

2.12 PIPE PENETRATIONS

- A. Pipe penetration sleeves will be installed for all pipe other than rectangular blocked out floor openings for risers in mechanical bays.
- B. Pipe penetration sleeve materials will comply with all firestopping requirements for each penetration.
- C. To prevent accidental liquid spills from passing to a lower level, provide the following:
 - 1. For sleeves: Extend sleeve 1 inch above finished floor and provide sealant for watertight joint.
 - 2. For blocked out floor openings: Provide 1-1/2 inch angle set in silicone adhesive around opening.
 - 3. For drilled penetrations: Provide 1-1/2 inch angle ring or square set in silicone adhesive around penetration.
- D. Penetrations are prohibited through beams or ribs, but may be installed in concrete beam flanges, with structural engineer prior approval. Any deviation from these requirements must receive prior approval of COR.
- E. Sheet metal, plastic, or moisture resistant fiber sleeves will be provided for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.
- F. Cast iron or zinc coated pipe sleeves will be provided for pipe passing through exterior walls below grade. The space between the sleeve and pipe will be made watertight with a modular or link rubber seal. The link seal will be applied at both ends of the sleeve.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

- G. Galvanized steel or an alternate black iron pipe with asphalt coating sleeves will be for pipe passing through concrete beam flanges, except where brass pipe sleeves are called for. A galvanized steel sleeve will be provided for pipe passing through floor of mechanical rooms, laundry work rooms, and animal rooms above basement. Except in mechanical rooms, sleeves will be connected with a floor plate.
- H. Brass Pipe Sleeves will be provided for pipe passing through quarry tile, terrazzo or ceramic tile floors. The sleeve will be connected with a floor plate.
- I. Sleeve clearance through floors, walls, partitions, and beam flanges will be 1 inch greater in diameter than external diameter of pipe. Sleeve for pipe with insulation will be large enough to accommodate the insulation plus 1 inch in diameter. Interior openings will be caulked tight with firestopping material and sealant to prevent the spread of fire, smoke, water and gases.
- J. Sealant and Adhesives: Will be as specified in Section 07 92 00, JOINT SEALANTS. Bio-based materials will be utilized when possible.
- K. Pipe passing through roof will be installed through a 4.9 kg per square meter copper flashing with an integral skirt or flange. Skirt or flange will extend not less than 8 inches from the pipe and set in a solid coating of bituminous cement. Extend flashing a minimum of 10 inches up the pipe. Pipe passing through a waterproofing membrane will be provided with a clamping flange. The annular space between the sleeve and pipe will be sealed watertight.

2.13 TOOLS AND LUBRICANTS

- A. Furnish, and turn over to the COR, special tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.
- B. Grease Guns with Attachments for Applicable Fittings: One for each type of grease required for each motor or other equipment.
- C. Tool Containers: metal, permanently identified for intended service and mounted, or located, where directed by the COR.
- D. Lubricants: A minimum of 1 quart of oil, and 1 pound of grease, of equipment manufacturer's recommended grade and type, in unopened

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

containers and properly identified as to use for each different application. Bio-based materials will be utilized when possible.

2.14 WALL, FLOOR AND CEILING PLATES

- A. Material and Type: Chrome plated brass or chrome plated steel, one piece or split type with concealed hinge, with set screw for fastening to pipe, or sleeve. Use plates that fit tight around pipes, cover openings around pipes and cover the entire pipe sleeve projection.
- B. Thickness: Not less than 3/32 inch for floor plates. For wall and ceiling plates, not less than 0.025 inch for up to 3 inch pipe, 0.035 inch for larger pipe.
- C. Locations: Use where pipe penetrates floors, walls and ceilings in exposed locations, in finished areas only. Wall plates will be used where insulation ends on exposed water supply pipe drop from overhead. A watertight joint will be provided in spaces where brass or steel pipe sleeves are specified.

2.15 ASBESTOS

- A. Materials containing asbestos are prohibited.

PART 3 - EXECUTION

3.1 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING

- A. Location of piping, sleeves, inserts, hangers, and equipment, access provisions will be coordinated with the work of all trades. Piping, sleeves, inserts, hangers, and equipment will be located clear of windows, doors, openings, light outlets, and other services and utilities. Equipment layout drawings will be prepared to coordinate proper location and personnel access of all facilities. The drawings will be submitted for review.
- B. Manufacturer's published recommendations will be followed for installation methods not otherwise specified.
- C. Operating Personnel Access and Observation Provisions: All equipment and systems will be arranged to provide clear view and easy access, without use of portable ladders, for maintenance, testing and operation of all devices including, but not limited to: all equipment items, valves, backflow preventers, filters, strainers, transmitters, sensors, meters and control devices. All gauges and indicators will be clearly visible by personnel standing on the floor or on permanent platforms.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

Maintenance and operating space and access provisions that are shown in the drawings will not be changed nor reduced.

- D. Structural systems necessary for pipe and equipment support will be coordinated to permit proper installation.
- E. Location of pipe sleeves, trenches and chases will be accurately coordinated with equipment and piping locations.
- F. Cutting Holes:
 - 1. Holes will be located to avoid interference with structural members such as beams or grade beams. Holes will be laid out in advance and drilling done only after approval by COR. If the Contractor considers it necessary to drill through structural members, this matter will be referred to COR for approval.
 - 2. Waterproof membrane will not be penetrated. Pipe floor penetration block outs will be provided outside the extents of the waterproof membrane.
 - 3. Holes through concrete and masonry will be cut by rotary core drill. Pneumatic hammer, impact electric, and hand or manual hammer type drill will not be allowed, except as permitted by COR where working area space is limited.
- G. Minor Piping: Generally, small diameter pipe runs from drips and drains, water cooling, and other services are not shown but must be provided.
- H. Protection and Cleaning:
 - 1. Equipment and materials will be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations and as approved by the COR. Damaged or defective items in the opinion of the COR, will be replaced at no additional cost or time to the Government.
 - 2. Protect all finished parts of equipment, such as shafts and bearings where accessible, from rust prior to operation by means of protective grease coating and wrapping. Close pipe openings with caps or plugs during installation. Pipe openings, equipment, and plumbing fixtures will be tightly covered against dirt or mechanical injury. At completion of all work thoroughly clean fixtures, exposed materials and equipment.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

- I. Concrete and Grout: Concrete and shrink compensating grout 25 MPa (3000 psig) minimum, specified in Section 03 30 00, CAST-IN-PLACE CONCRETE, will be used for all pad or floor mounted equipment.
- J. Gauges, thermometers, valves and other devices will be installed with due regard for ease in reading or operating and maintaining said devices. Thermometers and gauges will be located and positioned to be easily read by operator or staff standing on floor or walkway provided. Servicing will not require dismantling adjacent equipment or pipe work.
- K. Interconnection of Controls and Instruments: Electrical interconnection is generally not shown but will be provided. This includes interconnections of sensors, transmitters, transducers, control devices, control and instrumentation panels, alarms, instruments and computer workstations. Comply with NFPA 70.
- L. Domestic cold and hot water systems interface with the HVAC control system for the temperature, pressure and flow monitoring requirements to mitigate legionella. See the HVAC control points list and Section 23 09 23, DIRECT DIGITAL CONTROL SYSTEM FOR HVAC.
- M. Work in Existing Building:
 - 1. Perform as specified in Article, OPERATIONS AND STORAGE AREAS, Article, ALTERATIONS, and Article, RESTORATION of the Section 01 00 00, GENERAL REQUIREMENTS for relocation of existing equipment, alterations and restoration of existing building(s).
 - 2. As specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, OPERATIONS AND STORAGE AREAS, make alterations to existing service piping at times that will cause the least interfere with normal operation of the facility.
- N. Work in Animal Research Areas: Seal all pipe penetrations with silicone sealant to prevent entrance of insects.
- O. Work in bathrooms, restrooms, housekeeping closets: All pipe penetrations behind escutcheons will be sealed with plumbers' putty.
- P. Switchgear Drip Protection: Every effort will be made to eliminate the installation of pipe above data equipment, and electrical and telephone switchgear. If this is not possible, encase pipe in a second pipe with a minimum of joints. Drain valve will be provided in low point of casement pipe.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

Q. Inaccessible Equipment:

1. Where the Government determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, equipment will be removed and reinstalled or remedial action performed as directed at no additional cost or additional time to the Government.
2. The term "conveniently accessible" is defined as capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as electrical conduit, motors, fans, pumps, belt guards, transformers, high voltage lines, piping, and ductwork.

3.2 TEMPORARY PIPING AND EQUIPMENT

- A. Continuity of operation of existing facilities may require temporary installation or relocation of equipment and piping. Temporary equipment or pipe installation or relocation will be provided to maintain continuity of operation of existing facilities.
- B. The Contractor will provide all required facilities in accordance with the requirements of phased construction and maintenance of service. All piping and equipment will be properly supported, sloped to drain, operate without excessive stress, and will be insulated where injury can occur to personnel by contact with operating facilities. The requirements of paragraph 3.1 will apply.
- C. Temporary facilities and piping will be completely removed back to the nearest active distribution branch or main pipe line and any openings in structures sealed. Dead legs are prohibited in potable water systems. Necessary blind flanges and caps will be provided to seal open piping remaining in service.

3.3 RIGGING

- A. Openings in building structures will be planned to accommodate design scheme.
- B. Alternative methods of equipment delivery may be offered and will be considered by Government under specified restrictions of phasing and service requirements as well as structural integrity of the building.
- C. All openings in the building will be closed when not required for rigging operations to maintain proper environment in the facility for Government operation and maintenance of service.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

- D. Contractor will provide all facilities required to deliver specified equipment and place on foundations. Attachments to structures for rigging purposes and support of equipment on structures will be Contractor's full responsibility.
- E. Contractor will check all clearances, weight limitations and will provide a rigging plan designed by a Registered Professional Engineer. All modifications to structures, including reinforcement thereof, will be at Contractor's cost, time and responsibility.
- F. Rigging plan and methods will be referred to COR for evaluation prior to actual work.

3.4 PIPE AND EQUIPMENT SUPPORTS

- A. Where hanger spacing does not correspond with joist or rib spacing, use structural steel channels secured directly to joist and rib structure that will correspond to the required hanger spacing, and then suspend the equipment and piping from the channels. Holes will be drilled or burned in structural steel ONLY with the prior written approval of the COR.
- B. The use of chain pipe supports, wire or strap hangers; wood for blocking, stays and bracing, or hangers suspended from piping above will not be permitted. Rusty products will be replaced.
- C. Hanger rods will be used that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. A minimum of 1/2 inch clearance between pipe or piping covering and adjacent work will be provided.
- D. For horizontal and vertical plumbing pipe supports, refer to the International Plumbing Code (IPC) and these specifications.
- E. Overhead Supports:
 - 1. The basic structural system of the building is designed to sustain the loads imposed by equipment and piping to be supported overhead.
 - 2. Provide steel structural members, in addition to those shown, of adequate capability to support the imposed loads, located in accordance with the final approved layout of equipment and piping.
 - 3. Tubing and capillary systems will be supported in channel troughs.
- F. Floor Supports:
 - 1. Provide concrete bases, concrete anchor blocks and pedestals, and structural steel systems for support of equipment and piping.

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

- Concrete bases and structural systems will be anchored and doweled to resist forces under operating and seismic conditions (if applicable) without excessive displacement or structural failure.
2. Bases and supports will not be located and installed until equipment mounted thereon has been approved. Bases will be sized to match equipment mounted thereon plus 2 inch excess on all edges. Structural drawings will be reviewed for additional requirements. Bases will be neatly finished and smoothed, will have chamfered edges at the top, and will be suitable for painting.
 3. All equipment will be shimmed, leveled, firmly anchored, and grouted with epoxy grout. Anchor bolts will be placed in sleeves, anchored to the bases. Fill the annular space between sleeves and bolts with a grout material to permit alignment and realignment.
 4. For seismic anchoring, refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

3.5 LUBRICATION

- A. All equipment and devices requiring lubrication will be lubricated prior to initial operation. All devices and equipment will be field checked for proper lubrication.
- B. All devices and equipment will be equipped with required lubrication fittings. A minimum of 1 quart of oil and 1 pound of grease of manufacturer's recommended grade and type for each different application will be provided. All materials will be delivered to COR in unopened containers that are properly identified as to application.
- C. A separate grease gun with attachments for applicable fittings will be provided for each type of grease applied.
- D. All lubrication points will be accessible without disassembling equipment, except to remove access plates.
- E. All lubrication points will be extended to one side of the equipment.

3.6 PLUMBING SYSTEMS DEMOLITION

- A. Rigging access, other than indicated in the drawings, will be provided after approval for structural integrity by the COR. Such access will be provided at no additional cost or time to the Government. Where work is in an operating plant, approved protection from dust and debris will be provided at all times for the safety of plant personnel and maintenance of plant operation and environment of the plant.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

- B. In an operating plant, cleanliness and safety will be maintained. The plant will be kept in an operating condition. Government personnel will be carrying on their normal duties of operating, cleaning and maintaining equipment and plant operation. Work will be confined to the immediate area concerned; maintain cleanliness and wet down demolished materials to eliminate dust. Dust and debris will not be permitted to accumulate in the area to the detriment of plant operation. All flame cutting will be performed to maintain the fire safety integrity of this plant. Adequate fire extinguishing facilities will be available at all times. All work will be performed in accordance with recognized fire protection standards including NFPA 51B. Inspections will be made by personnel of the VAMC, and the Contractor will follow all directives of the COR with regard to rigging, safety, fire safety, and maintenance of operations.
- C. Unless specified otherwise, all piping, wiring, conduit, and other devices associated with the equipment not re-used in the new work will be completely removed from Government property per Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT. This includes all concrete equipment pads, pipe, valves, fittings, insulation, and all hangers including the top connection and any fastenings to building structural systems. All openings will be sealed after removal of equipment, pipes, ducts, and other penetrations in roof, walls, floors, in an approved manner and in accordance with plans and specifications where specifically covered. Structural integrity of the building system will be maintained. Reference will also be made to the drawings and specifications of the other disciplines in the project for additional facilities to be demolished or handled.
- D. All valves including gate, globe, ball, butterfly and check, all pressure gauges and thermometers with wells will remain Government property and will be removed and delivered to COR and stored as directed. The Contractor will remove all other material and equipment, devices and demolition debris under these plans and specifications. Such material will be removed from Government property expeditiously and will not be allowed to accumulate. Coordinate with the COR and Infection Control.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

E. Asbestos Insulation Removal: Conform to Section 02 82 11, TRADITIONAL ASBESTOS ABATEMENT.

3.7 CLEANING AND PAINTING

A. Prior to final inspection and acceptance of the plant and facilities for beneficial use by the Government, the plant facilities, equipment and systems will be thoroughly cleaned and painted. Refer to Section 09 91 00, PAINTING.

B. In addition, the following special conditions apply:

1. Cleaning will be thorough. Solvents, cleaning materials and methods recommended by the manufacturers will be used for the specific tasks. All rust will be removed prior to painting and from surfaces to remain unpainted. Scratches, scuffs, and abrasions will be repaired prior to applying prime and finish coats.
2. The following Material and Equipment will NOT be painted:
 - a. Motors, controllers, control switches, and safety switches.
 - b. Control and interlock devices.
 - c. Regulators.
 - d. Pressure reducing valves.
 - e. Control valves and thermostatic elements.
 - f. Lubrication devices and grease fittings.
 - g. Copper, brass, aluminum, stainless steel and bronze surfaces.
 - h. Valve stems and rotating shafts.
 - i. Pressure gauges and thermometers.
 - j. Glass.
 - k. Name plates.
3. Control and instrument panels will be cleaned and damaged surfaces repaired. Touch-up painting will be made with matching paint type and color obtained from manufacturer or computer matched.
4. Pumps, motors, steel and cast-iron bases, and coupling guards will be cleaned, and will be touched-up with the same paint type and color as utilized by the pump manufacturer.
5. Temporary Facilities: Apply paint to surfaces that do not have existing finish coats per Section 09 91 00, Painting.
6. The final result will be a smooth, even-colored, even-textured factory finish on all items. The entire piece of equipment will be

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

repainted, if necessary, to achieve this. Lead based paints will not be used.

3.8 IDENTIFICATION SIGNS

- A. Laminated plastic signs, with engraved lettering not less than 3/16 inch high, will be provided that designates equipment function, for all equipment, switches, motor controllers, relays, meters, control devices, including automatic control valves. Nomenclature and identification symbols will correspond to that used in maintenance manual, and in diagrams specified elsewhere. Attach by chain, adhesive, or screws.
- B. Factory Built Equipment: Metal plate, securely attached, with name and address of manufacturer, serial number, model number, size, and performance data will be placed on factory-built equipment.
- C. Pipe Identification: Refer to Section 09 91 00, PAINTING.

3.9 STARTUP AND TEMPORARY OPERATION

- A. Startup of equipment will be performed as described in the equipment specifications. Vibration within specified tolerance will be verified prior to extended operation. Temporary use of equipment is specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TEMPORARY USE OF MECHANICAL AND ELECTRICAL EQUIPMENT.
- B. The CxA will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the Contracting Officer's Representative and CxA. Provide a minimum of two weeks prior notice.

3.10 OPERATING AND PERFORMANCE TESTS

- A. Prior to the final inspection, all required tests will be performed as specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TESTS and submit the test reports and records to the COR.
- B. Should evidence of malfunction in any tested system, or piece of equipment or component part thereof, occur during or as a result of tests, make proper corrections, repairs or replacements, and repeat tests at no additional cost to the Government.
- C. When completion of certain work or systems occurs at a time when final control settings and adjustments cannot be properly made to make performance tests, then conduct such performance tests and finalize control settings during the first actual seasonal use of the respective

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

systems following completion of work. Rescheduling of these tests will be requested in writing to COR for approval.

- D. Perform tests as required for commissioning provisions in accordance with Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS and Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

3.11 OPERATION AND MAINTENANCE MANUALS

- A. All new and temporary equipment and all elements of each assembly will be included.
- B. Data sheet on each device listing model, size, capacity, pressure, speed, horsepower, impeller size, and other information will be included.
- C. Manufacturer's installation, maintenance, repair, and operation instructions for each device will be included. Assembly drawings and parts lists will also be included. A summary of operating precautions and reasons for precautions will be included in the Operations and Maintenance Manual.
- D. Lubrication instructions, type and quantity of lubricant will be included.
- E. Schematic diagrams and wiring diagrams of all control systems corrected to include all field modifications will be included.
- F. Set points of all interlock devices will be listed.
- G. Trouble-shooting guide for the control system troubleshooting will be inserted into the Operations and Maintenance Manual.
- H. The control system sequence of operation corrected with submittal review comments will be inserted into the Operations and Maintenance Manual.
- I. Emergency procedures for shutdown and startup of equipment and systems.

3.12 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
- B. Components provided under this section of the specification will be tested as part of a larger system.

3.13 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-23

- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

- - - E N D - - -

SECTION 22 05 23
GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section describes the requirements for general-duty valves for domestic water and sewer systems.
- B. A complete listing of common acronyms and abbreviations are included in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA AND SAMPLES.
- C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.
- D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
- E. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
- F. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.
- B. American Society of Mechanical Engineers (ASME):
A112.14.1-2003.....Backwater Valves
- C. American Society of Sanitary Engineering (ASSE):
1001-2017.....Performance Requirements for Atmospheric Type Vacuum Breakers
1003-2009.....Performance Requirements for Water Pressure Reducing Valves for Domestic Water Distribution Systems
1011-2017.....Performance Requirements for Hose Connection Vacuum Breakers
1013-2011.....Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Principle Fire Protection Backflow Preventers

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

09-01-20

- 1015-2011.....Performance Requirements for Double Check
Backflow Prevention Assemblies and Double Check
Fire Protection Backflow Prevention Assemblies
- 1017-2009.....Performance Requirements for Temperature
Actuated Mixing Valves for Hot Water
Distribution Systems
- 1020-2004.....Performance Requirements for Pressure Vacuum
Breaker Assembly
- 1035-2008.....Performance Requirements for Laboratory Faucet
Backflow Preventers
- 1069-2005.....Performance Requirements for Automatic
Temperature Control Mixing Valves
- 1070-2015.....Performance Requirements for Water Temperature
Limiting Devices
- 1071-2012.....Performance Requirements for Temperature
Actuated Mixing Valves for Plumbed Emergency
Equipment
- D. American Society for Testing and Materials (ASTM):
- A126-2004 (R2019).....Standard Specification for Gray Iron Castings
for Valves, Flanges, and Pipe Fittings
- A276/A276M-2017.....Standard Specification for Stainless Steel Bars
and Shapes
- A536-1984 (R2019e).....Standard Specification for Ductile Iron
Castings
- B62-2017.....Standard Specification for Composition Bronze
or Ounce Metal Castings
- B584-2014.....Standard Specification for Copper Alloy Sand
Castings for General Applications
- E. International Code Council (ICC):
- IPC-2018.....International Plumbing Code
- F. Manufacturers Standardization Society of the Valve and Fittings
Industry, Inc. (MSS):
- SP-25-2018.....Standard Marking Systems for Valves, Fittings,
Flanges and Unions
- SP-67-2017.....Butterfly Valves

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

09-01-20

SP-70-2011.....Gray Iron Gate Valves, Flanged and Threaded
Ends

SP-71-2018.....Gray Iron Swing Check Valves, Flanged and
Threaded Ends

SP-80-2019.....Bronze Gate, Globe, Angle, and Check Valves

SP-85-2011.....Gray Iron Globe & Angle Valves, Flanged and
Threaded Ends

SP-110-2010.....Ball Valves Threaded, Socket-Welding, Solder
Joint, Grooved and Flared Ends

G. National Environmental Balancing Bureau (NEBB):

8th Edition 2015 Procedural Standards for Testing, Adjusting,
Balancing of Environmental Systems

H. NSF International (NSF):

61-2019.....Drinking Water System Components - Health
Effects

372-2016.....Drinking Water System Components - Lead Content

I. University of Southern California Foundation for Cross Connection
Control and Hydraulic Research (USC FCCCHR):

10th Edition.....Manual of Cross-Connection Control

1.4 SUBMITTALS

- A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING", with applicable paragraph identification.
- C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
 - 1. Ball Valves.
 - 2. Gate Valves.
 - 3. Butterfly Valves.
 - 4. Balancing Valves.
 - 5. Check Valves.
 - 6. Globe Valves.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

09-01-20

7. Water Pressure Reducing Valves and Connections.
8. Backwater Valves.
9. Backflow Preventers.
10. Thermostatic Mixing Valves.
- D. Test and Balance reports for balancing valves.
- E. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replaceable parts and troubleshooting guide:
 1. Include complete list indicating all components of the systems.
 2. Include complete diagrams of the internal wiring for each item of equipment.
 3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.
 4. Piping diagrams of thermostatic mixing valves to be installed.
- F. Completed System Readiness Checklist provided by the CxA and completed by the Contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
- G. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Valves shall be prepared for shipping as follows:
 1. Protect internal parts against rust and corrosion.
 2. Protect threads, flange faces, grooves, and weld ends.
 3. Set angle, gate, and globe valves closed to prevent rattling.
 4. Set ball and plug valves open to minimize exposure of functional surfaces.
 5. Set butterfly valves closed or slightly open.
 6. Block check valves in either closed or open position.
- B. Valves shall be prepared for storage as follows:
 1. Maintain valve end protection.
 2. Store valves indoors and maintain at higher than ambient dew point temperature.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

09-01-20

- C. A sling shall be used for large valves. The sling shall be rigged to avoid damage to exposed parts. Hand wheels or stems shall not be used as lifting or rigging points.

1.6 AS BUILT DOCUMENTATION

- A. Comply with requirements in Paragraph "AS-BUILT DOCUMENTATION" of Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

PART 2 - PRODUCTS

2.1 VALVES, GENERAL

- A. Asbestos packing and gaskets are prohibited.
- B. Bronze valves shall be made with dezincification resistant materials. Bronze valves made with copper alloy (brass) containing greater than 15 percent zinc shall not be permitted.
- C. Valves in insulated piping shall have 50 mm or DN50 (2 inch) stem extensions and extended handles of non-thermal conductive material that allows operating the valve without breaking the vapor seal or disturbing the insulation. Memory stops shall be fully adjustable after insulation is applied.
- D. Exposed Valves over 65 mm or DN65 (2-1/2 inches) installed at an elevation over 3.6 m (12 feet) shall have a chain-wheel attachment to valve hand-wheel, stem, or other actuator.
- E. All valves used to supply potable water shall meet the requirements of NSF 61 and NSF 372.
- F. Bio-Based Materials: For products designated by the USDA's bio-based Bio-Preferred Program, provide products that meet or exceed USDA recommendations for bio-based content, so long as products meet all performance requirements in this specifications section. For more information regarding the product categories covered by the Bio-Preferred Program, visit <http://www.biopreferred.gov>.
- G. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.

2.2 SHUT-OFF VALVES

- A. Cold, Hot and Re-circulating Hot Water:
1. 50 mm or DN50 (2 inches) and smaller: Ball, MSS SP-110, Ball valve shall be full port three piece or two piece with a union design with adjustable stem package. Threaded stem designs are not allowed. The ball valve shall have a SWP rating of 1035 kPa (150 psig) and a CWP

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

09-01-20

- rating of 4138 kPa (600 psig). The body material shall be Bronze ASTM B584. The ends shall be non-lead solder.
2. Less than 100 mm DN100 (4 inches): Butterfly shall have an iron body with EPDM seal and aluminum bronze disc. The butterfly valve shall meet MSS SP-67, type I standard. The butterfly valve shall have a SWP rating of 1380 kPa (200 psig). The valve design shall be lug type suitable for bidirectional dead-end service at rated pressure. The body material shall meet ASTM A536, ductile iron.
 3. 100 mm DN100 (4 inches) and greater:
 - a. Class 125, OS&Y, Cast Iron Gate Valve. The gate valve shall meet MSS SP-70 type I standard. The gate valve shall have a CWP rating of 1380 kPa (200 psig). The valve materials shall meet ASTM A126, grey iron with bolted bonnet, flanged ends, bronze trim, and positive-seal resilient solid wedge disc. The gate valve shall be gear operated for sizes under 200 mm or DN200 (8 inches) and crank operated for sizes 200 mm or DN200 (8 inches) and greater.
 - b. Single flange, ductile iron butterfly valves: The single flanged butterfly valve shall meet the MSS SP-67 standard. The butterfly valve shall have a CWP rating of 1380 kPa (200 psig). The butterfly valve shall be lug type, suitable for bidirectional dead-end service at rated pressure without use of downstream flange. The body material shall comply with ASTM A536 ductile iron. The seat shall be EPDM with stainless steel disc and stem.
 - c. Grooved end, ductile iron butterfly valves. The grooved butterfly valve shall meet the MSS SP-67 standard. The grooved butterfly valve shall have a CWP rating of 1380 kPa (200 psig). The valve materials shall be epoxy coated ductile iron conforming to ASTM A536 with two-piece stainless-steel stem, EPDM encapsulated ductile iron disc, and EPDM seal. The butterfly valve shall be gear operated.
- B. Reagent Grade Water: Valves for reagent grade, reverse osmosis, or deionized water service shall be ball type of same material as used for pipe.

2.3 MANUAL BALANCING VALVES

- A. Hot Water Re-circulating, 75 mm or DN75 (3 inches) and smaller manual balancing valve shall be of bronze body, brass ball construction with

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

09-01-20

glass and carbon filled TFE seat rings and designed for positive shutoff. The manual balancing valve shall have differential pressure read-out ports across the valve seat area. The read out ports shall be fitted with internal EPT inserts and check valves. The valve body shall have 8 mm or DN8 NPT (1/4 inch NPT) tapped drain and purge port. The valves shall have memory stops that allow the valve to close for service and then reopened to set point without disturbing the balance position. All valves shall have calibrated nameplates to assure specific valve settings.

- B. Greater than 75 mm or DN75 (3 inches): Manual balancing valves shall be of heavy duty cast iron flanged construction with 861 kPa (125 psig) flange connections. The flanged manual balancing valves shall have either a brass ball with glass and carbon filled TFE seal rings or fitted with a bronze seat, replaceable bronze disc with EPDM seal insert and stainless steel stem. The design pressure shall be 1200 kPa (175 psig) at 121 degrees C (250 degrees F).

2.4 THERMOSTATIC BALANCING VALVES (NOT USED)

2.5 CHECK VALVES

- A. 75 mm or DN75 (3 inches) and smaller shall be Class 125, bronze swing check valves with non-metallic disc suitable for type of service. The check valve shall meet MSS SP-80 Type 4 standard. The check valve shall have a CWP rating of 1380 kPa (200 psig). The check valve shall have a Y pattern horizontal body design with bronze body material conforming to ASTM B62, solder joints, and PTFE or TFE disc.
- B. 100 mm or DN100 (4 inches) and greater:
1. Check valves shall be Class 125, iron swing check valve with lever and weight closure control. The check valve shall meet MSS SP-71 Type I standard. The check valve shall have a CWP rating of 1380 kPa (200 psig). The check valve shall have a clear or full waterway body design with gray iron body material conforming to ASTM A126, bolted bonnet, flanged ends, bronze trim.
 2. All check valves on the discharge side of submersible sump pumps shall have factory installed exterior level and weight with sufficient weight to prevent the check valve from hammering against the seat when the sump pump stops.

09-01-20

2.6 GLOBE VALVES

- A. 75 mm or DN75 (3 inches) or smaller: Class 150, bronze globe valve with non-metallic disc. The globe valve shall meet MSS SP-80, Type 2 standard. The globe valve shall have a CWP rating of 2070 kPa (300 psig). The valve material shall be bronze with integral seal and union ring bonnet conforming to ASTM B62 with solder ends, copper-silicon bronze stem, PTFE or TFE disc, and malleable iron hand wheel.
- B. Greater than 75 mm or DN75 (3 inches): Similar to above, except with cast iron body and bronze trim, Class 125, iron globe valve. The globe valve shall meet MSS SP-85, Type 1 standard. The globe valve shall have a CWP rating of 1380 kPa (200 psig). The valve material shall be gray iron with bolted bonnet conforming to ASTM A126 with flanged ends, bronze trim, and malleable iron handwheel.

2.7 WATER PRESSURE REDUCING VALVE AND CONNECTIONS

- A. 75 mm or DN75 (3 inches) or smaller: The pressure reducing valve shall consist of a bronze body and bell housing, a separate access cover for the plunger, and a bolt to adjust the downstream pressure. The pressure reducing valve shall meet ASSE 1003. The bronze bell housing and access cap shall be threaded to the body and shall not require the use of ferrous screws. The assembly shall be of the balanced piston design and shall reduce pressure in both flow and no flow conditions. The assembly shall be accessible for maintenance without having to remove the body from the line.
- B. 100 mm or DN100 (4 inches) and greater: The pressure reducing valve shall consist of a flanged cast iron body and rated to 1380 kPa (200 psig). The valve shall have a large elastomer diaphragm for sensitive response. The pressure reducing valve shall meet ASSE 1003.
- C. The regulator shall have a tap for pressure gauge.
- D. The regulator shall have a temperature rating of 100 degrees C (212 degrees F) for hot water or hot water return service. Pressure regulators shall have accurate pressure regulation to 6.9 kPa (+/- 1 psig).
- E. Setting: Entering water pressure, discharge pressure, capacity, size, and related measurements shall be as shown on the drawings.
- F. Connections Valves and Strainers: Shut off valves shall be installed on each side of reducing valve and a bypass line equal in size to the

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

09-01-20

regulator inlet pipe shall be installed with a normally closed globe valve. A strainer shall be installed on inlet side of, and same size as pressure reducing valve. A pressure gauge shall be installed on the inlet and outlet of the valve.

2.8 BACKWATER VALVE

- A. The backwater valve shall have a cast iron body, automatic thermoplastic type valve seat and flapper suited for water service. The flapper shall be slightly open during periods of non-operation. The pressure reducing valve shall meet ASME A112.14.1. The cleanout shall be extended to the finish floor and fit with a threaded countersunk plug. A clamping device shall be included when the cleanout extends through the waterproofing membrane.
- B. When the backwater valve is installed greater than 600 mm (24 inches) below the finish floor elevation, a pit or manhole large enough for a repair person can enter to service the backwater valve shall be installed.

2.9 BACKFLOW PREVENTERS

- A. A backflow prevention assembly shall be installed at any point in the plumbing system where the potable water supply comes in contact with a potential source of contamination. The backflow prevention assembly shall be approved by the University of Southern California Foundation for Cross Connection Control and Hydraulic Research (USCFCCC).
- B. The reduced pressure principle backflow prevention assembly shall be ASSE listed 1013 with full port OS&Y positive-seal resilient gate valves and an integral relief monitor switch. The main body and access cover shall be epoxy coated ductile iron conforming to ASTM A536 grade 4. The seat ring and check valve shall be the thermoplastic type suited for water service. The stem shall be stainless steel conforming to ASTM A276/A276M. The seat disc shall be the elastomer type suited for water service. The checks and the relief valve shall be accessible for maintenance without removing the device from the line. An epoxy coated wye type strainer with flanged connections shall be installed on the inlet. Reduced pressure backflow preventers shall be installed in the following applications.

- 1. Deionizers.
- 2. Sterilizers.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

09-01-20

3. Dialysis, Deionized or Reverse Osmosis Water Systems.
 4. Water make up to heating systems, cooling tower, chilled water system, generators, and similar equipment consuming water.
 5. Water service entrance from loop system.
 6. Dental equipment.
 7. Power washer.
 8. Medical equipment.
 9. Process equipment.
 10. Autopsy, on each hot and cold water outlet at each table or sink.
 11. Reclaimed water systems.
- C. The pipe applied or integral atmospheric vacuum breaker shall be ASSE listed 1001. The main body shall be cast bronze. The seat disc shall be the elastomer type suited for water service. The device shall be accessible for maintenance without removing the device from the service line. The installation shall not be in a concealed or inaccessible location or where the venting of water from the device during normal operation is deemed objectionable. Atmospheric vacuum breakers shall be installed in the following applications.
1. Hose bibs and sinks with threaded outlets.
 2. Disposers.
 3. Showers (telephone/handheld type).
 4. Hydrotherapy units.
 5. All kitchen equipment, if not protected by air gap.
 6. Ventilating hoods with wash down system.
 7. Film processor.
 8. Detergent system.
 9. Fume hoods.
 10. Glassware washers.
 11. Service sinks (integral with faucet only).
 12. Laundry tubs (integral with faucet only).
 13. Sitz baths.
- D. The hose connection vacuum breaker shall be ASSE listed 1011. The main body shall be cast brass with stainless steel working parts. The diaphragm and disc shall be the elastomer type suited for water service. The device shall permit the attachment of portable hoses to hose thread outlets. Hose connection vacuum breakers shall be

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

09-01-20

installed in the following locations requiring non-continuous pressure:

1. Hose bibbs and wall hydrants.
- E. The pressure vacuum breaker shall be ASSE listed 1020. The main body shall be brass. The disc and O-ring seal shall be the elastomer type. The valve seat and disc float shall be the thermoplastic type. Tee handle or lever handle shut-off ball valves. Test cocks for testing and draining where freezing conditions occur. All materials shall be suitable for water service. The device shall be accessible for maintenance without removing the device from the service line. The installation shall not be in a concealed or inaccessible location or where the venting of water from the device during normal operation is deemed objectionable. Pressure vacuum breakers shall be installed in the following locations requiring continuous pressure and no backpressure including equipment with submerged inlet connections:
1. 1. Lawn Irrigation.
- F. The laboratory faucet vacuum breaker shall be ASSE listed 1035. The main body shall be cast brass. Dual check valves with stainless steel working parts. The diaphragm and disc shall be the elastomer type suited for water service. The device shall permit the attachment of portable hoses to laboratory faucets for non-continuous pressure applications.
- G. The double check backflow prevention assembly shall be ASSE listed 1015 and supply with full port, OS&Y, positive-seal, resilient gate valves. The main body and access cover shall be epoxy coated ductile iron conforming to ASTM A536 grade. The seat ring and check valve shall be the thermoplastic type suited for water service. The stem shall be stainless steel conforming to ASTM A276/A276M. The seat disc shall be the elastomer type suited for water service. The first and second check valve shall be accessible for maintenance without removing the device from the line. Double check valves shall be installed in the following location requiring continuous pressure subject to backpressure and backsiphonage conditions.
1. Lawn Irrigation.
 2. Food Processing Equipment.
 3. Laundry equipment.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

09-01-20

2.10 CHAINWHEELS (NOT USED)

2.11 THERMOSTATIC MIXING VALVES

- A. Thermostatic Mixing Valves shall comply with the following general performance requirements:
1. Shall meet ASSE requirements for water temperature control.
 2. The body shall be cast bronze or brass with corrosion resistant internal parts preventing scale and biofilm build-up. Provide chrome-plated finish in exposed areas.
 3. No special tool shall be required for temperature adjustment, maintenance, replacing parts and disinfecting operations.
 4. Valve shall be able to be placed in various positions without making temperature adjustment or reading difficult.
 5. Valve finish shall be chrome plated in exposed areas.
 6. Valve shall allow easy temperature adjustments to allow hot water circulation. Internal parts shall be able to withstand disinfecting operations of chemical and thermal treatment of water temperatures up to 82°C (180°F) for 30 minutes or 50 mg/L (50 ppm) chlorine residual concentration for 24 hours.
 7. Parts shall be easily removed or replaced without dismantling the valves, for easy scale removal and disinfecting of parts.
 8. Valve shall have a manual adjustable temperature control with locking mechanism to prevent tampering by end user. Outlet temperature shall be visible to ensure outlet temperature does not exceed specified limits, particularly after thermal eradication procedures.
 9. Provide mixing valves with integral check valves with screens and stop valves.
- B. Master Thermostatic Water Mixing Valves:
1. Application: Tempered water distribution from hot water source.
 2. Standard: ASSE 1017.
 3. Pressure Rating: 861 kPa (125 psig).
 4. Type: Exposed-mounting or Cabinet-type, as indicated, thermostatically controlled water mixing valve.
 5. Connections: Flanged or threaded union inlets and outlet.
 6. Valve Finish: Chrome plated.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

09-01-20

7. Cabinet: Factory-fabricated, stainless steel, for recessed or surface mounting and with hinged, stainless-steel door.
8. Thermometers shall be provided to indicate mixed water temperature.
9. Provide a high temperature alarm device to detect mixing valve failure.

C. Hi-Lo Water-Mixing-Valve Assemblies:

1. Application: Tempered water distribution from hot water source covering a wide range of flow.
2. Description: Factory-fabricated, cabinet-type or exposed-mounting, thermostatically controlled, water-mixing-valve assembly in two-valve parallel arrangement including pressure regulators, pressure gauges and thermometer.
3. Large-Flow Parallel: Master thermostatic water mixing valve and downstream pressure regulator with pressure gauges on inlet and outlet.
4. Small-Flow Parallel: Master thermostatic water mixing valve.
5. Master Thermostatic Mixing Valves: Comply with ASSE 1017.
6. Water Regulator(s): Comply with ASSE 1003. Include pressure gauge on inlet and outlet.
7. Component Pressure Ratings: 861 kPa (125 psig) minimum, unless otherwise indicated.
8. Cabinet: Factory-fabricated, stainless steel, for recessed or surface mounting and with hinged, stainless-steel door.
9. Connections: Soldered or threaded union inlets and outlet.
10. Thermometers shall be provided to indicate mixed water temperature.
11. Provide a high temperature alarm device to detect mixing valve failure.

D. Automatic Water Temperature Control Mixing Valves:

1. Application: Gang plumbing fixtures point-of-use when no other mixing at fixtures occurs.
2. Standard: ASSE 1069.
3. Pressure Rating: 861 kPa (125 psig).
4. Type: Thermostatically controlled water mixing valve set at 43 degrees C (110 degrees F).
5. Connections: Threaded union or soldered inlets and outlet.
6. Thermometers shall be provided to indicate mixed water temperature.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

09-01-20

7. Upon cold water supply failure the hot water flow shall automatically be reduced to 0.5 gpm maximum.
8. Provide a high temperature alarm device to detect mixing valve failure.

E. Water Temperature Limiting Devices:

1. Application: Single plumbing fixture point-of-use such as sinks or lavatories.
2. Standard: ASSE 1070.
3. Pressure Rating: 861 kPa (125 psig).
4. Type: Thermostatically controlled water mixing valve set at 43 degrees C (110 degrees F).
5. Connections: Threaded union, compression or soldered inlets and outlet.
6. Upon cold water supply failure the hot water flow shall automatically be reduced to 0.2 gpm maximum.

F. Temperature Activated Mixing Valves:

1. Application: Emergency eye/face/drench shower equipment.
2. Standard: ASSE 1071.
3. Pressure Rating: 861 kPa (125 psig).
4. Type: Thermostatically controlled water mixing valve set at 24-30 degrees C (75-85 degrees F).
5. Connections: Soldered or threaded union inlets and outlet.
6. Cabinet: Factory-fabricated, stainless steel, for recessed or surface mounting and with hinged, stainless-steel door.
7. Thermometers shall be provided to indicate mixed water temperature.
8. Upon cold water supply failure the hot water flow shall automatically be reduced to 0.5 gpm maximum.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Valve interior shall be examined for cleanliness, freedom from foreign matter, and corrosion. Special packing materials shall be removed, such as blocks, used to prevent disc movement during shipping and handling.
- B. Valves shall be operated in positions from fully open to fully closed. Guides and seats shall be examined and made accessible by such operations.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

09-01-20

- C. Threads on valve and mating pipe shall be examined for form and cleanliness.
- D. Mating flange faces shall be examined for conditions that might cause leakage. Bolting shall be checked for proper size, length, and material. Gaskets shall be verified for proper size and that its material composition is suitable for service and free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

3.2 INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Valves shall be located for easy access and shall be provide with separate support. Valves shall be accessible with access doors when installed inside partitions or above hard ceilings.
- C. Valves shall be installed in horizontal piping with stem at or above center of pipe.
- D. Valves shall be installed in a position to allow full stem movement.
- E. Check valves shall be installed for proper direction of flow and as follows:
 - 1. Swing Check Valves: In horizontal position with hinge pin level and on top of valve.
- F. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that shall be sources of contamination. Comply with authorities having jurisdiction. Locate backflow preventers in same room as connected equipment or system.
 - 1. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are prohibited for this application.
- G. Install pressure gauges on outlet of backflow preventers.
- H. Do not install bypass piping around backflow preventers.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

09-01-20

- I. Install temperature-actuated water mixing valves with check stops or shutoff valves on inlets.
 - 1. Install thermometers if specified.
 - 2. Install cabinet-type units recessed in or surface mounted on wall as specified.
- J. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.
- K. Install thermostatic balancing valves with inlet strainer and inlet and outlet isolation valves.

3.3 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
 - 1. Calibrated balancing valves.
 - 2. Master, thermostatic, water mixing valves.
 - 3. Manifold, thermostatic, water-mixing-valve assemblies.
- B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit.

3.4 ADJUSTING

- A. Valve packing shall be adjusted or replaced after piping systems have been tested and put into service but before final adjusting and balancing. Valves shall be replaced if persistent leaking occurs.
- B. Set field-adjustable flow set points of balancing valves and record data. Ensure recorded data represents actual measured or observed conditions. Permanently mark settings of valves and other adjustment devices allowing settings to be restored. Set and lock memory stops. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- C. Set field-adjustable temperature set points of temperature-actuated water mixing valves.
- D. Testing and adjusting of balancing valves shall be performed by an independent NEBB Accredited Test and Balance Contractor. A final settings and flow report shall be submitted to the VA Contracting Officer's Representative (COR).

09-01-20

3.5 STARTUP AND TESTING

- A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.
- B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.
- C. The CxA will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and CxA. Provide a minimum notice of 10 working days prior to startup and testing.

3.6 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
- B. Components provided under this section of the specification will be tested as part of a larger system.

3.7 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

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Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-1-16

SECTION 22 08 00
COMMISSIONING OF PLUMBING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The requirements of this Section apply to all sections of Division 22.
- B. This project will have selected building systems commissioned. The complete list of equipment and systems to be commissioned are specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. The commissioning process, which the Contractor is responsible to execute, is defined in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. A Commissioning Agent (CxA) appointed by the Department of Veterans Affairs will manage the commissioning process.

1.2 RELATED WORK

- A. Section 01 00 00 GENERAL REQUIREMENTS.
- B. Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.
- C. Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

1.3 SUMMARY

- A. This Section includes requirements for commissioning plumbing systems, subsystems and equipment. This Section supplements the general requirements specified in Section 01 91 00 General Commissioning Requirements.
- B. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for more specifics regarding processes and procedures as well as roles and responsibilities for all Commissioning Team members.

1.4 DEFINITIONS

- A. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for definitions.

1.5 COMMISSIONED SYSTEMS

- A. Commissioning of a system or systems specified in Division 22 is part of the construction process. Documentation and testing of these systems, as well as training of the VA's Operation and Maintenance personnel in accordance with the requirements of Section 01 91 00 and of Division 22, is required in cooperation with the VA and the Commissioning Agent.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-1-16

- B. The Plumbing systems commissioning will include the systems listed in Section 01 91 00 General Commissioning Requirements:

1.6 SUBMITTALS

- A. The commissioning process requires review of selected Submittals. The Commissioning Agent will provide a list of submittals that will be reviewed by the Commissioning Agent. This list will be reviewed and approved by the VA prior to forwarding to the Contractor. Refer to Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, and SAMPLES for further details.
- B. The commissioning process requires Submittal review simultaneously with engineering review. Specific submittal requirements related to the commissioning process are specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CONSTRUCTION INSPECTIONS

- A. Commissioning of the Building Plumbing Systems will require inspection of individual elements of the Plumbing construction throughout the construction period. The Contractor shall coordinate with the Commissioning Agent in accordance with Section 01 91 00 and the Commissioning Plan to schedule inspections as required to support the commissioning process.

3.2 PRE-FUNCTIONAL CHECKLISTS

- A. The Contractor shall complete Pre-Functional Checklists to verify systems, subsystems, and equipment installation is complete and systems are ready for Systems Functional Performance Testing. The Commissioning Agent will prepare Pre-Functional Checklists to be used to document equipment installation. The Contractor shall complete the checklists. Completed checklists shall be submitted to the VA and to the Commissioning Agent for review. The Commissioning Agent may spot check a sample of completed checklists. If the Commissioning Agent determines that the information provided on the checklist is not accurate, the Commissioning Agent will return the marked-up checklist to the Contractor for correction and resubmission. If the Commissioning Agent determines that a significant number of completed

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-1-16

checklists for similar equipment are not accurate, the Commissioning Agent will select a broader sample of checklists for review. If the Commissioning Agent determines that a significant number of the broader sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and resubmission. Refer to SECTION 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for submittal requirements for Pre-Functional Checklists, Equipment Startup Reports, and other commissioning documents.

3.3 CONTRACTORS TESTS

- A. Contractor tests as required by other sections of Division 22 shall be scheduled and documented in accordance with Section 01 00 00 GENERAL REQUIREMENTS. . All testing shall be incorporated into the project schedule. Contractor shall provide no less than 7 calendar days' notice of testing. The Commissioning Agent will witness selected Contractor tests at the sole discretion of the Commissioning Agent. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.4 SYSTEMS FUNCTIONAL PERFORMANCE TESTING:

- A. The Commissioning Process includes Systems Functional Performance Testing that is intended to test systems functional performance under steady state conditions, to test system reaction to changes in operating conditions, and system performance under emergency conditions. The Commissioning Agent will prepare detailed Systems Functional Performance Test procedures for review and approval by the Contracting Officer's Representative. The Contractor shall review and comment on the tests prior to approval. The Contractor shall provide the required labor, materials, and test equipment identified in the test procedure to perform the tests. The Commissioning Agent will witness and document the testing. The Contractor shall sign the test reports to verify tests were performed. See Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS, for additional details.

3.5 TRAINING OF VA PERSONNEL

- A. Training of the VA operation and maintenance personnel is required in cooperation with the Contracting Officer's Representative and Commissioning Agent. Provide competent, factory authorized personnel

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-1-16

to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. Contractor shall submit training agendas and trainer resumes in accordance with the requirements of Section 01 91 00. The instruction shall be scheduled in coordination with the Contracting Officer's Representative after submission and approval of formal training plans. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS and Division 22 Sections for additional Contractor training requirements.

----- **END** -----

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-21

SECTION 22 11 00
FACILITY WATER DISTRIBUTION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Domestic water systems, including piping, equipment and all necessary accessories as designated in this section.
- B. A complete listing of all acronyms and abbreviations are included in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.
- D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
- E. Section 07 84 00, FIRESTOPPING.
- F. Section 07 92 00, JOINT SEALANTS.
- G. Section 09 91 00, PAINTING.
- H. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
- I. Section 22 07 11, PLUMBING INSULATION.
- J. SECTION 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Mechanical Engineers (ASME):
 - A13.1-2007 (R2013).....Scheme for Identification of Piping Systems
 - B16.3-2011.....Malleable Iron Threaded Fittings: Classes 150 and 300
 - B16.9-2012.....Factory-Made Wrought Buttwelding Fittings
 - B16.11-2011.....Forged Fittings, Socket-Welding and Threaded
 - B16.12-2009 (R2014).....Cast Iron Threaded Drainage Fittings
 - B16.15-2013 Cast Copper Alloy Threaded Fittings: Classes 125 and 250
 - B16.18-2012.....Cast Copper Alloy Solder Joint Pressure Fittings

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-21

- B16.22-2013.....Wrought Copper and Copper Alloy Solder-Joint
Pressure Fittings
- B16.24-2011.....Cast Copper Alloy Pipe Flanges and Flanged
Fittings: Classes 150, 300, 600, 900, 1500, and
2500
- ASME Boiler and Pressure Vessel Code -
BPVC Section IX-2015....Welding, Brazing, and Fusing Qualifications
- C. American Society of Sanitary Engineers (ASSE):
1010-2004.....Performance Requirements for Water Hammer
Arresters
- D. American Society for Testing and Materials (ASTM):
A47/A47M-1999 (R2014)...Standard Specification for Ferritic Malleable
Iron Castings
- A53/A53M-2012.....Standard Specification for Pipe, Steel, Black
and Hot-Dipped, Zinc-Coated, Welded and
Seamless
- A183-2014.....Standard Specification for Carbon Steel Track
Bolts and Nuts
- A269/A269M-2014e1.....Standard Specification for Seamless and Welded
Austenitic Stainless Steel Tubing for General
Service
- A312/A312M-2015.....Standard Specification for Seamless, Welded,
and Heavily Cold Worked Austenitic Stainless
Steel Pipes
- A403/A403M-2014.....Standard Specification for Wrought Austenitic
Stainless Steel Piping Fittings
- A536-1984 (R2014).....Standard Specification for Ductile Iron
Castings
- A733-2013.....Standard Specification for Welded and Seamless
Carbon Steel and Austenitic Stainless Steel
Pipe Nipples
- B32-2008 (R2014).....Standard Specification for Solder Metal
- B43-2014.....Standard Specification for Seamless Red Brass
Pipe, Standard Sizes
- B61-2008 (R2013).....Standard Specification for Steam or Valve
Bronze Castings

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-21

B62-2009.....Standard Specification for Composition Bronze
or Ounce Metal Castings
B75/B75M-2011.....Standard Specification for Seamless Copper Tube
B88-2014.....Standard Specification for Seamless Copper
Water Tube
B584-2014.....Standard Specification for Copper Alloy Sand
Castings for General Applications
B687-1999 (R2011).....Standard Specification for Brass, Copper, and
Chromium-Plated Pipe Nipples
C919-2012.....Standard Practice for Use of Sealants in
Acoustical Applications
D1785-2012.....Standard Specification for Poly (Vinyl
Chloride) (PVC) Plastic Pipe, Schedules 40, 80,
and 120
D2000-2012.....Standard Classification System for Rubber
Products in Automotive Applications
D2564-2012.....Standard Specification for Solvent Cements for
Poly (Vinyl Chloride) (PVC) Plastic Piping
Systems
D2657-2007.....Standard Practice for Heat Fusion Joining of
Polyolefin Pipe and Fittings
D2855-1996 (R2010).....Standard Practice for Making Solvent-Cemented
Joints with Poly (Vinyl Chloride) (PVC) Pipe
and Fittings
D4101-2014.....Standard Specification for Polypropylene
Injection and Extrusion Materials
E1120-2008.....Standard Specification for Liquid Chlorine
E1229-2008.....Standard Specification for Calcium Hypochlorite
F2389-2010.....Standard Specification for Pressure-rated
Polypropylene (PP) Piping Systems
F2620-2013.....Standard Practice for Heat Fusion Joining of
Polyethylene Pipe and Fittings
F2769-2014.....Standard Specification for Polyethylene of
Raised Temperature (PE-RT) Plastic Hot and
Cold-Water Tubing and Distribution Systems

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-21

E. American Water Works Association (AWWA):

C110-2012.....Ductile-Iron and Gray-Iron Fittings
C151-2009.....Ductile Iron Pipe, Centrifugally Cast
C153-2011.....Ductile-Iron Compact Fittings
C203-2008.....Coal-Tar Protective Coatings and Linings for
Steel Water Pipelines - Enamel and Tape - Hot
Applied
C213-2007.....Fusion-Bonded Epoxy Coating for the Interior
and Exterior of Steel Water Pipelines
C651-2014.....Disinfecting Water Mains

F. American Welding Society (AWS):

A5.8M/A5.8-2011-AMD1....Specification for Filler Metals for Brazing and
Braze Welding

G. International Code Council (ICC):

IPC-2012.....International Plumbing Code

H. Manufacturers Specification Society (MSS):

SP-58-2009.....Pipe Hangers and Supports - Materials, Design,
Manufacture, Selection, Application, and
Installation
SP-72-2010a.....Ball Valves with Flanged or Butt-Welding Ends
for General Service
SP-110-2010.....Ball Valves Threaded, Socket-Welding, Solder
Joint, Grooved and Flared Ends

I. NSF International (NSF):

14-2015.....Plastics Piping System Components and Related
Materials
61-2014a.....Drinking Water System Components - Health
Effects
372-2011.....Drinking Water System Components - Lead Content

J. Plumbing and Drainage Institute (PDI):

PDI-WH 201-2010.....Water Hammer Arrestors

K. Department of Veterans Affairs:

H-18-8-2013.....Seismic Design Handbook
H-18-10.....Plumbing Design Manual

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-21

1.4 SUBMITTALS

- A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 22 11 00, FACILITY WATER DISTRIBUTIONS", with applicable paragraph identification.
- C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
 - 1. All items listed in Part 2 - Products.
- D. Complete operating and maintenance manuals including wiring diagrams, technical data sheets and information for ordering replacement parts:
 - 1. Include complete list indicating all components of the systems.
 - 2. Include complete diagrams of the internal wiring for each item of equipment.
 - 3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.
- E. Completed System Readiness Checklist provided by the CxA and completed by the Contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
- F. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.5 QUALITY ASSURANCE

- A. A certificate shall be submitted prior to welding of steel piping showing the Welder's certification. The certificate shall be current and no more than one year old. Welder's qualifications shall be in accordance with ASME BPVC Section IX.
- B. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be by the same manufacturer as the groove components.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-21

- C. All pipe, couplings, fittings, and specialties shall bear the identification of the manufacturer and any markings required by the applicable referenced standards.
- D. Bio-Based Materials: For products designated by the USDA's Bio-Preferred Program, provide products that meet or exceed USDA recommendations for bio-based content, so long as products meet all performance requirements in this specifications section. For more information regarding the product categories covered by the Bio-Preferred Program, visit <http://www.biopreferred.gov>.

1.6 SPARE PARTS (NOT USED)

1.7 AS-BUILT DOCUMENTATION

- A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be in electronic version on compact disc or DVD inserted into a three-ring binder. All aspects of system operation and maintenance procedures, including piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A list of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.
- C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them in Auto-CAD version 2010 provided on compact disk or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-21

- D. Certification documentation shall be provided to COR 10 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and certificate if applicable that all results of tests were within limits specified. If a certificate is not available, all documentation shall be on the Certifier's letterhead.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Material or equipment containing a weighted average of greater than 0.25 percent lead are prohibited in any potable water system intended for human consumption and shall be certified in accordance with NSF 61 or NSF 372. Endpoint devices used to dispense water for drinking shall meet the requirements of NSF 61, Section 9.
- B. Plastic pipe, fittings, and solvent cement shall meet NSF 14 and shall be NSF listed for the service intended.

2.2 UNDERGROUND WATER SERVICE CONNECTIONS TO BUILDINGS (NOT USED)

2.3 ABOVE GROUND (INTERIOR) WATER PIPING

- A. Pipe: Copper tube, ASTM B88, Type K or L, drawn. For pipe 6 inches and larger, stainless steel, ASTM A312, schedule 40 shall be used.
- B. Fittings for Copper Tube:
1. Wrought copper or bronze castings conforming to ASME B16.18 and B16.22. Unions shall be bronze, MSS SP-72, MSS SP-110, solder or braze joints. Use 95/5 tin and antimony for all soldered joints.
 2. Mechanical press-connect fittings for copper pipe and tube **are prohibited**. See Plumbing Design Manual for additional information.
 3. Mechanically formed tee connection: Form mechanically extracted collars in a continuous operation by drilling pilot hole and drawing out tube surface to form collar, having a height of not less than three times the thickness of tube wall. Adjustable collaring device shall ensure proper tolerance and complete uniformity of the joint. Notch and dimple joining branch tube in a single process to provide free flow where the branch tube penetrates the fitting. Braze joints.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-21

5. Flanged fittings, bronze, class 150, solder-joint ends conforming to ASME B16.24.

C. Fittings for Stainless Steel:

1. Stainless steel butt-welded fittings, Type 316, Schedule 10, conforming to ASME B16.9.

D. Adapters: Provide adapters for joining pipe or tubing with dissimilar end connections.

E. Solder: ASTM B32 alloy type Sb5, HA or HB. Provide non-corrosive flux.

F. Brazing alloy: AWS A5.8M/A5.8, brazing filler metals shall be BCuP series for copper to copper joints and BA9 series for copper to steel joints.

2.4 EXPOSED WATER PIPING

A. Finished Room: Use full iron pipe size chrome plated brass piping for exposed water piping connecting fixtures, casework, cabinets, equipment, and reagent racks when not concealed by apron including those furnished by the Government or specified in other sections.

1. Pipe: ASTM B43, standard weight.

2. Fittings: ASME B16.15 cast bronze threaded fittings with chrome finish.

3. Nipples: ASTM B687, Chromium-plated.

4. Unions: MSS SP-72, MSS SP-110, brass or bronze with chrome finish. Unions 2-1/2 inches and larger shall be flange type with approved gaskets.

B. Unfinished Rooms, Mechanical Rooms and Kitchens: Chrome-plated brass piping is not required. Paint piping systems as specified in Section 09 91 00, PAINTING.

2.5 ETHYLENE OXIDE (ETO) STERILIZER WATER SUPPLY PIPING (NOT USED)

2.6 TRAP PRIMER WATER PIPING

A. Pipe: Copper tube, ASTM B88, type K, hard drawn.

B. Fittings: Bronze castings conforming to ASME B16.18 Solder joints.

C. Solder: ASTM B32 alloy type Sb5. Provide non-corrosive flux.

2.7 STRAINERS (NOT USED)

2.8 DIELECTRIC FITTINGS

A. Provide dielectric couplings or unions between pipe of dissimilar metals.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-21

2.9 STERILIZATION CHEMICALS (NOT USED)

2.10 WATER HAMMER ARRESTER

A. Closed copper tube chamber with permanently sealed 413 kPa (60 psig) air charge above a Double O-ring piston. Two high heat Buna-N O-rings pressure packed and lubricated with FDA approved silicone compound. All units shall be designed in accordance with ASSE 1010. Access shall be provided where devices are concealed within partitions or above ceilings. Size and install in accordance with PDI-WH 201 requirements. Provide water hammer arrestors at:

1. All solenoid valves.
2. All groups of two or more flush valves.
3. All quick opening or closing valves.
4. All medical washing equipment.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Comply with the International Plumbing Code and the following:

1. Install branch piping for water from the piping system and connect to all fixtures, valves, cocks, outlets, casework, cabinets and equipment, including those furnished by the Government or specified in other sections.
2. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe, except for plastic and glass, shall be reamed to remove burrs and a clean smooth finish restored to full pipe inside diameter.
3. All pipe runs shall be laid out to avoid interference with other work/trades.
4. Install union and shut-off valve on pressure piping at connections to equipment.
5. Pipe Hangers, Supports and Accessories:
 - a. All piping shall be supported per the IPC, H-18-8 Seismic Design Handbook, MSS SP-58, and SMACNA as required.
 - b. Shop Painting and Plating: Hangers, supports, rods, inserts and accessories used for pipe supports shall be shop coated with zinc chromate primer paint. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-21

c. Floor, Wall and Ceiling Plates, Supports, Hangers:

- 1) Solid or split un-plated cast iron.
- 2) All plates shall be provided with set screws.
- 3) Pipe Hangers: Height adjustable clevis type.
- 4) Adjustable Floor Rests and Base Flanges: Steel.
- 5) Concrete Inserts: "Universal" or continuous slotted type.
- 6) Hanger Rods: Mild, low carbon steel, fully threaded or Threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.
- 7) Pipe Hangers and Riser Clamps: Malleable iron or carbon steel. Pipe Hangers and riser clamps shall have a copper finish when supporting bare copper pipe or tubing.
- 8) Rollers: Cast iron.
- 9) Self-drilling type expansion shields shall be "Phillips" type, with case hardened steel expander plugs.
- 10) Hangers and supports utilized with insulated pipe and tubing shall have 180-degree (minimum) metal protection shield centered on and welded to the hanger and support. The shield thickness and length shall be engineered and sized for distribution of loads to preclude crushing of insulation without breaking the vapor barrier. The shield shall be sized for the insulation and have flared edges to protect vapor-retardant jacket facing. To prevent the shield from sliding out of the clevis hanger during pipe movement, center-ribbed shields shall be used.
- 11) Miscellaneous Materials: As specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories. If the vertical distance exceeds 20 feet for cast iron pipe additional support shall be provided in the center of that span. Provide all necessary auxiliary steel to provide that support.
- 12) With the installation of each flexible expansion joint, provide piping restraints for the upstream and downstream section of the piping at the flexible expansion joint. Provide calculations supporting the restraint length design and type of selected restraints. Restraint calculations shall be based

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-21

on the criteria from the manufacturer regarding their
restraint design.

6. Install chrome plated cast brass escutcheon with set screw at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.

7. Penetrations:

- a. Firestopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke, and gases as specified in Section 07 84 00, FIRESTOPPING. Completely fill and seal clearances between raceways and openings with the firestopping materials.
- b. Waterproofing: At floor penetrations, completely seal clearances around the pipe and make watertight with sealant as specified in Section 07 92 00, JOINT SEALANTS. Bio-based materials shall be utilized when possible.
- c. Acoustical sealant: Where pipes pass through sound rated walls, seal around the pipe penetration with an acoustical sealant that is compliant with ASTM C919.

B. Domestic Water piping shall conform to the following:

1. Grade all lines to facilitate drainage. Provide drain valves at bottom of risers and all low points in system. Design domestic hot and cold water circulating lines with no traps.
2. Connect branch lines at bottom of main serving fixtures below and pitch down so that main may be drained through fixture. Connect branch lines to top of main serving only fixtures located on floor above.

3.2 TESTS

- A. General: Test system either in its entirety or in sections. Submit testing plan to COR 10 working days prior to test date.
- B. Potable Water System: Test after installation of piping and domestic water heaters, but before piping is concealed, before covering is applied, and before plumbing fixtures are connected. Fill systems with water and maintain hydrostatic pressure of 1035 kPa (150 psig) gage for two hours. No decrease in pressure is allowed. Provide a pressure gage

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

05-01-21

with a shutoff and bleeder valve at the highest point of the piping being tested. Pressure gauge shall have 1 psig increments.

C. All Other Piping Tests: Test new installed piping under 1-1/2 times actual operating conditions and prove tight.

D. The test pressure shall hold for the minimum time duration required by the applicable plumbing code or authority having jurisdiction.

3.3 STERILIZATION

A. After tests have been successfully completed, thoroughly flush and sterilize the interior domestic water distribution system in accordance with AWWA C651.

B. Use liquid chlorine or hypochlorite for sterilization.

3.4 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.5 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer's technical representative for four hours to instruct VA Personnel in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

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Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-20

SECTION 22 13 00
FACILITY SANITARY AND VENT PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section pertains to sanitary sewer and vent systems, including piping, equipment and all necessary accessories as designated in this section.
- B. A complete listing of common acronyms and abbreviations are included in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.
- D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
- E. Section 07 84 00, FIRESTOPPING: Penetrations in rated enclosures.
- F. Section 07 92 00, JOINT SEALANTS: Sealant products.
- G. Section 09 91 00, PAINTING: Preparation and finish painting and identification of piping systems.
- H. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING: Pipe Hangers and Supports, Materials Identification.
- I. Section 22 07 11, PLUMBING INSULATION.
- J. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.
- B. American Society of Mechanical Engineers (ASME):
 - A13.1-2007.....Identification of Piping Systems
 - A112.36.2M-1991.....Cleanouts
 - A112.6.3-2019.....Floor and Trench Drains
 - B1.20.1-2013.....Pipe Threads, General Purpose (Inch)
 - B16.1-2015.....Gray Iron Pipe Flanges and Flanged Fittings
 - Classes 25, 125, and 250
 - B16.4-2016.....Grey Iron Threaded Fittings Classes 125 and 250

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-20

- B16.15-2018.....Cast Copper Alloy Threaded Fittings, Classes
125 and 250
- B16.18-2018.....Cast Copper Alloy Solder Joint Pressure
Fittings
- B16.21-2016.....Nonmetallic Flat Gaskets for Pipe Flanges
- B16.22-2018.....Wrought Copper and Copper Alloy Solder-Joint
Pressure Fittings
- B16.23-2016.....Cast Copper Alloy Solder Joint Drainage
Fittings: DWV
- B16.24-2016.....Cast Copper Alloy Pipe Flanges and Flanged
Fittings, and Valves: Classes 150, 300, 600,
900, 1500, and 2500
- B16.29-2017.....Wrought Copper and Wrought Copper Alloy Solder-
Joint Drainage Fittings: DWV
- B16.39-2014.....Malleable Iron Threaded Pipe Unions Classes
150, 250, and 300
- B18.2.1-2012.....Square, Hex, Heavy Hex, and Askew Head Bolts
and Hex, Heavy Hex, Hex Flange, Lobed Head, and
Lag Screws (Inch Series)
- C. American Society of Sanitary Engineers (ASSE):
- 1001-2017.....Performance Requirements for Atmospheric Type
Vacuum Breakers
- 1018-2001.....Performance Requirements for Trap Seal Primer
Valves - Potable Water Supplied
- 1044-2015.....Performance Requirements for Trap Seal Primer
Devices - Drainage Types and Electronic Design
Types
- 1079-2012.....Performance Requirements for Dielectric Pipe
Unions
- D. American Society for Testing and Materials (ASTM):
- A53/A53M-2018.....Standard Specification for Pipe, Steel, Black
And Hot-Dipped, Zinc-coated, Welded and
Seamless
- A74-2017.....Standard Specification for Cast Iron Soil Pipe
and Fittings

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-20

A888-2018a.....Standard Specification for Hubless Cast Iron
Soil Pipe and Fittings for Sanitary and Storm
Drain, Waste, and Vent Piping Applications
B32-2008 (R2014).....Standard Specification for Solder Metal
B43-2015.....Standard Specification for Seamless Red Brass
Pipe, Standard Sizes
B88-2016.....Standard Specification for Seamless Copper
Water Tube
B306-2013.....Standard Specification for Copper Drainage Tube
(DWV)
B687-1999 (R2016).....Standard Specification for Brass, Copper, and
Chromium-Plated Pipe Nipples
B813-2016.....Standard Specification for Liquid and Paste
Fluxes for Soldering of Copper and Copper Alloy
Tube
B828-2016.....Standard Practice for Making Capillary Joints
by Soldering of Copper and Copper Alloy Tube
and Fittings
C564-2014.....Standard Specification for Rubber Gaskets for
Cast Iron Soil Pipe and Fittings
D2321-2018.....Standard Practice for Underground Installation
of Thermoplastic Pipe for Sewers and Other
Gravity-Flow Applications
D2564-2012 (R3018).....Standard Specification for Solvent Cements for
Poly(Vinyl Chloride) (PVC) Plastic Piping
Systems
D2665-2014.....Standard Specification for Poly(Vinyl Chloride)
(PVC) Plastic Drain, Waste, and Vent Pipe and
Fittings
D2855-2015.....Standard Practice for Two-Step (Primer and
Solvent Cement) Method of Joining Poly(Vinyl
Chloride) (PVC) or Chlorinated Poly (Vinyl
Chloride) CPVCP Pipe and Piping Components with
Tapered Sockets

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-20

- D5926-2015.....Standard Specification for Poly(Vinyl Chloride)
(PVC) Gaskets for Drain, Waste, and Vent (DWV),
Sewer, Sanitary, and Storm Plumbing Systems
- F402-2018.....Standard Practice for Safe Handling of Solvent
Cements, Primers, and Cleaners Used for Joining
Thermoplastic Pipe and Fittings
- F477-2014.....Standard Specification for Elastomeric Seals
(Gaskets) for Joining Plastic Pipe
- F1545-2015e1.....Standard Specification for Plastic-Lined
Ferrous Metal Pipe, Fittings, and Flanges
- E. Cast Iron Soil Pipe Institute (CISPI):
- 2006.....Cast Iron Soil Pipe and Fittings Handbook
- 301-2012.....Standard Specification for Hubless Cast Iron
Soil Pipe and Fittings for Sanitary and Storm
Drain, Waste, and Vent Piping Applications
- 310-2012.....Specification for Coupling for Use in
Connection with Hubless Cast Iron Soil Pipe and
Fittings for Sanitary and Storm Drain, Waste,
and Vent Piping Applications
- F. Copper Development Association, Inc. (CDA):
- A4015-14/19.....Copper Tube Handbook
- G. International Code Council (ICC):
- IPC-2018.....International Plumbing Code
- H. Manufacturers Standardization Society (MSS):
- SP-123-2018.....Non-Ferrous Threaded and Solder-Joint Unions
for Use with Copper Water Tube
- I. National Fire Protection Association (NFPA):
- 70-2020.....National Electrical Code (NEC)
- J. Underwriters' Laboratories, Inc. (UL):
- 508-99 (R2013).....Standard For Industrial Control Equipment

1.4 SUBMITTALS

- A. Submittals, including number of required copies, shall be submitted in
accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and
SAMPLES.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-20

- B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 22 13 00, FACILITY SANITARY AND VENT PIPING", with applicable paragraph identification.
- C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
1. Piping.
 2. Floor Drains.
 3. Cleanouts.
 4. Trap Seal Protection.
 5. Penetration Sleeves.
 6. Pipe Fittings.
 7. Traps.
 8. Exposed Piping and Fittings.
- D. Detailed shop drawing of clamping device and extensions when required in connection with the waterproofing membrane or the floor drain.
- E. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replaceable parts, and troubleshooting guide:
1. Include complete list indicating all components of the systems.
 2. Include complete diagrams of the internal wiring for each item of equipment.
 3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.
- F. Completed System Readiness Checklist provided by the CXA and completed by the Contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
- G. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.5 QUALITY ASSURANCE

- A. Bio-Based Materials: For products designated by the USDA's bio-based Bio-Preferred Program, provide products that meet or exceed USDA recommendations for bio-based content, so long as products meet all

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-20

performance requirements in this specifications section. For more information regarding the product categories covered by the Bio-Preferred Program, visit <http://www.biopreferred.gov>.

- B. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.

1.6 AS-BUILT DOCUMENTATION

- A. Comply with requirements in Paragraph "AS-BUILT DOCUMENTATION" of Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

PART 2 - PRODUCTS

2.1 SANITARY WASTE, DRAIN, AND VENT PIPING

- A. Cast iron waste, drain, and vent pipe and fittings.
1. Cast iron waste, drain, and vent pipe and fittings shall be used for the following applications:
 - a. Pipe buried in or in contact with earth.
 - b. Sanitary pipe extensions to a distance of approximately 5 feet outside of the building.
 - c. Interior waste and vent piping above grade.
 2. Cast iron Pipe shall be bell and spigot or hubless (plain end or no-hub or hubless).
 3. The material for all pipe and fittings shall be cast iron soil pipe and fittings and shall conform to the requirements of CISPI 301, ASTM A888, or ASTM A74.
 4. Cast iron pipe and fittings shall be made from a minimum of 95 percent post-consumer recycled material.
 5. Joints for hubless pipe and fittings shall conform to the manufacturer's installation instructions. Couplings for hubless joints shall conform to CISPI 310. Joints for hub and spigot pipe shall be installed with compression gaskets conforming to the requirements of ASTM C564.
- B. Copper Tube, (DWV):
1. Copper DWV tube sanitary waste, drain and vent pipe may be used for piping above ground, except for urinal drains.
 2. The copper DWV tube shall be drainage type, drawn temper conforming to ASTM B306.
 3. The copper drainage fittings shall be cast copper or wrought copper conforming to ASME B16.23 or ASME B16.29.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-20

4. The joints shall be lead free, using a water flushable flux, and conforming to ASTM B32.

2.2 PUMP DISCHARGE PIPING (NOT USED)

2.3 EXPOSED WASTE PIPING

- A. Chrome plated brass piping of full iron pipe size shall be used in finished rooms for exposed waste piping connecting fixtures, casework, cabinets, equipment and reagent racks when not concealed by apron including those furnished by the Government or specified in other sections.
1. The Pipe shall meet ASTM B43, regular weight.
 2. The Fittings shall conform to ASME B16.15.
 3. Nipples shall conform to ASTM B687, Chromium-plated.
 4. Unions shall be brass or bronze with chrome finish. Unions 2-1/2 inches and larger shall be flange type with approved gaskets.
- B. In unfinished Rooms such as mechanical Rooms and Kitchens, Chrome-plated brass piping is not required. The pipe materials specified under the paragraph "Sanitary Waste, Drain, and Vent Piping" can be used. The sanitary pipe in unfinished rooms shall be painted as specified in Section 09 91 00, PAINTING.

2.4 SPECIALTY PIPE FITTINGS

- A. Transition pipe couplings shall join piping with small differences in outside diameters or different materials. End connections shall be of the same size and compatible with the pipes being joined. The transition coupling shall be elastomeric, sleeve type reducing or transition pattern and include shear and corrosion resistant metal, tension band and tightening mechanism on each end. The transition coupling sleeve coupling shall be of the following material:
1. For cast iron soil pipes, the sleeve material shall be rubber conforming to ASTM C564.
- B. The dielectric fittings shall conform to ASSE 1079 with a pressure rating of 125 psig at a minimum temperature of 180 degrees F. The end connection shall be solder joint copper alloy and threaded ferrous.
- C. Dielectric flange insulating kits shall be of non-conducting materials for field assembly of companion flanges with a pressure rating of 150 psig. The gasket shall be neoprene or phenolic. The bolt sleeves shall

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-20

be phenolic or polyethylene. The washers shall be phenolic with steel backing washers.

- D. The di-electric nipples shall be electroplated steel nipple complying with ASTM F1545 with a pressure rating of 300 psig at 225 degrees F. The end connection shall be male threaded. The lining shall be inert and noncorrosive propylene.

2.5 CLEANOUTS

- A. Cleanouts shall be the same size as the pipe, up to 4 inches; and not less than 4 inches for larger pipe. Cleanouts shall be easily accessible and shall be gastight and watertight. Minimum clearance of 24 inches shall be provided for clearing a clogged sanitary line.
- B. Floor cleanouts shall be gray iron housing with clamping device and round, secured, scoriated, gray iron cover conforming to ASME A112.36.2M. A gray iron ferrule with hubless, socket, inside calk or spigot connection and counter sunk, taper-thread, brass or bronze closure plug shall be included. The frame and cover material and finish shall be nickel-bronze copper alloy with a square shape. The cleanout shall be vertically adjustable for a minimum of 2 inches. When a waterproof membrane is used in the floor system, clamping collars shall be provided on the cleanouts. Cleanouts shall consist of wye fittings and eighth bends with brass or bronze screw plugs. Cleanouts in the resilient tile floors, quarry tile and ceramic tile floors shall be provided with square top covers recessed for tile insertion. In the carpeted areas, carpet cleanout markers shall be provided. Two way cleanouts shall be provided where indicated in the contract document and at every building exit. The loading classification for cleanouts in sidewalk areas or subject to vehicular traffic shall be heavy duty type.
- C. Cleanouts shall be provided at or near the base of the vertical stacks with the cleanout plug located approximately 24 inches above the floor. If there are no fixtures installed on the lowest floor, the cleanout shall be installed at the base of the stack. The cleanouts shall be extended to the wall access cover. Cleanout shall consist of sanitary tees. Nickel-bronze square frame and stainless steel cover with minimum opening of 6 by 6 inches shall be furnished at each wall cleanout.

Where the piping is concealed, a fixture trap or a fixture with
Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-20

integral trap, readily removable without disturbing concealed pipe, shall be accepted as a cleanout equivalent providing the opening to be used as a cleanout opening is the size required.

- D. In horizontal runs above grade, cleanouts shall consist of cast brass tapered screw plug in fitting or caulked/hubless cast iron ferrule. Plain end (hubless) piping in interstitial space or above ceiling may use plain end (hubless) blind plug and clamp.

2.6 FLOOR DRAINS

- A. General Data: floor drain shall comply with ASME A112.6.3. A caulking flange, inside gasket, or hubless connection shall be provided for connection to cast iron pipe, screwed or no hub outlets for connection to steel pipe. The drain connection shall be bottom outlet. A membrane clamp and extensions shall be provided, if required, where installed in connection with waterproof membrane. Puncturing membrane other than for drain opening shall not be permitted. Double drainage pattern floor drains shall have integral seepage pan for embedding into floor construction, and weep holes to provide adequate drainage from pan to drain pipe. For drains not installed in connection with a waterproof membrane, a flashing membrane, 24 inches square or another approved waterproof membrane shall be provided.
- B. Type B (FD-B) medium duty (non-traffic) floor drain shall comply with ASME A112.6.3. The type B floor drain shall be constructed of galvanized cast iron with medium duty nickel bronze grate, double drainage pattern, clamping device, without sediment bucket but with secondary strainer in bottom for large debris. The grate shall be 7 inches minimum.
- C. Type M (FD-M) medium duty (non-traffic) floor drain shall comply with ASME A112.6.3. The type M floor drain shall have a cast iron body, nickel bronze adjustable funnel strainer and clamping device. Funnel strainer shall consist of a perforated floor-level square or round grate and funnel extension for indirect waste. Cut-out grate below funnel. Minimum dimensions as follows:
1. Area of strainer and collar -36 square inches.
 2. Height of funnel - 3-3/4 inches.
 3. Diameter of lower portion of funnel -2 inches.
 4. Diameter of top portion of funnel -4 inches.

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-20

5. Provide paper collars for construction purposes.

2.7 TRAPS

A. Traps shall be provided on all sanitary branch waste connections from fixtures or equipment not provided with traps. Exposed brass shall be polished brass chromium plated with nipple and set screw escutcheons. Concealed traps may be rough cast brass or same material as the piping they are connected to. Slip joints are prohibited on sewer side of trap. Traps shall correspond to fittings on cast iron soil pipe or steel pipe respectively, and size shall be as required by connected service or fixture.

2.8 PRIMER VALVES AND TRAP SEAL PRIMER SYSTEMS

- A. Trap Primer (TP-1): The trap seal primer valve shall be hydraulic, supply type with a pressure rating of 125 psig and conforming to standard ASSE 1018.
1. The inlet and outlet connections shall be NPS 1/2 inch
 2. The trap seal primer valve shall be fully automatic with an all brass or bronze body.
 3. The trap seal primer valve shall be activated by a drop in building water pressure, no adjustment required.
 4. The trap seal primer valve shall include a manifold when serving two, three, or four traps.
 5. The manifold shall be omitted when serving only one trap.

2.9 PENETRATION SLEEVES

A. A sleeve flashing device shall be provided at points where pipes pass through membrane waterproofed floors or walls. The sleeve flashing device shall be manufactured, cast iron fitting with clamping device that forms a sleeve for the pipe floor penetration of the floor membrane. A galvanized steel pipe extension shall be included in the top of the fitting that shall extend 2 inches above finished floor and galvanized steel pipe extension in the bottom of the fitting that shall extend through the floor slab. A waterproof caulked joint shall be provided at the top hub.

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

A. The pipe installation shall comply with the requirements of the International Plumbing Code (IPC) and these specifications.

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-20

- B. Branch piping shall be installed for waste from the respective piping systems and connect to all fixtures, valves, cocks, outlets, casework, cabinets and equipment, including those furnished by the Government or specified in other sections.
- C. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe shall be reamed to full size after cutting.
- D. All pipe runs shall be laid out to avoid interference with other work.
- E. The piping shall be installed above accessible ceilings where possible.
- F. The piping shall be installed to permit valve servicing or operation.
- G. The piping shall be installed free of sags and bends.
- H. Seismic restraint shall be installed where required by code.
- I. Changes in direction for soil and waste drainage and vent piping shall be made using appropriate branches, bends and long sweep bends. Sanitary tees and short sweep quarter bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Long turn double wye branch and eighth bend fittings shall be used if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow greater than 90 degrees. Proper size of standard increaser and reducers shall be used if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- J. Cast iron piping shall be installed according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings"
- K. Aboveground copper tubing shall be installed according to Copper Development Association's (CDA) "Copper Tube Handbook".
- L. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

3.2 JOINT CONSTRUCTION

- A. Hub and spigot, cast iron piping with gasket joints shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-20

- B. Hub and spigot, cast iron piping with calked joints shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.
- C. Hubless or No-hub, cast iron piping shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless piping coupling joints.
- D. For threaded joints, thread pipe with tapered pipe threads according to ASME B1.20.1. The threads shall be cut full and clean using sharp disc cutters. Threaded pipe ends shall be reamed to remove burrs and restored to full pipe inside diameter. Pipe fittings and valves shall be joined as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is required by the pipe service.
 - 2. Pipe sections with damaged threads shall be replaced with new sections of pipe.
- E. Copper tube and fittings with soldered joints shall be joined according to ASTM B828. A water flushable, lead free flux conforming to ASTM B813 and a lead-free alloy solder conforming to ASTM B32 shall be used.

3.3 SPECIALTY PIPE FITTINGS

- A. Transition coupling shall be installed at pipe joints with small differences in pipe outside diameters.
- B. Dielectric fittings shall be installed at connections of dissimilar metal piping and tubing.

3.4 PIPE HANGERS, SUPPORTS AND ACCESSORIES

- A. All piping shall be supported according to the International Plumbing Code (IPC), Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, and these specifications. Where conflicts arise between these the code and Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING the most restrictive or the requirement that specifies supports with highest loading or shortest spacing shall apply.
- B. Hangers, supports, rods, inserts and accessories used for pipe supports shall be painted according to Section 09 91 00, PAINTING. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.
- C. Horizontal piping and tubing shall be supported within 300 mm (12 inches) of each fitting or coupling.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-20

- D. Horizontal cast iron piping shall be supported with the following maximum horizontal spacing and minimum hanger rod diameters:
1. NPS 1-1/2 inch to NPS 2 inch: 60 inches with 3/8 inch rod.
 2. NPS 3 inch: 60 inches with 1/2 inch rod.
 3. NPS 4 inch to NPS 5 inch: 60 inches with 5/8 inch rod.
 4. NPS 6 inch to NPS 8 inch: 60 inches with 3/4 inch rod.
- E. Vertical piping and tubing shall be supported at the base, at each floor, and at intervals no greater than 15 feet.
- F. In addition to the requirements in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, Floor, Wall and Ceiling Plates, Supports, Hangers shall have the following characteristics:
1. Solid or split unplated cast iron.
 2. All plates shall be provided with set screws.
 3. Height adjustable clevis type pipe hangers.
 4. Adjustable floor rests and base flanges shall be steel.
 5. Hanger rods shall be low carbon steel, fully threaded or threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.
 6. Riser clamps shall be malleable iron or steel.
 7. Rollers shall be cast iron.
 8. See Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, for requirements on insulated pipe protective shields at hanger supports.
- G. Miscellaneous materials shall be provided as specified, required, directed or as noted in the contract documents for proper installation of hangers, supports and accessories. If the vertical distance exceeds 20 feet for cast iron pipe additional support shall be provided in the center of that span. All necessary auxiliary steel shall be provided to provide that support.
- H. Cast escutcheon with set screw shall be provided at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.
- I. Penetrations:
1. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, a fire stop shall be installed that provides an effective barrier against the spread of fire, smoke and

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-20

- gases as specified in Section 07 84 00, FIRESTOPPING. Clearances between raceways and openings shall be completely filled and sealed with the fire stopping materials.
2. Water proofing: At floor penetrations, clearances shall be completely sealed around the pipe and make watertight with sealant as specified in Section 07 92 00, JOINT SEALANTS.
- J. Exhaust vents shall be extended separately through roof. Sanitary vents shall not connect to exhaust vents.

3.5 TESTS

- A. Sanitary waste and drain systems shall be tested either in its entirety or in sections.
- B. Waste System tests shall be conducted before trenches are backfilled or fixtures are connected. A water test or air test shall be conducted, as directed.
1. If entire system is tested for a water test, tightly close all openings in pipes except highest opening, and fill system with water to point of overflow. If the waste system is tested in sections, tightly plug each opening except highest opening of section under test, fill each section with water and test with at least a 10 foot head of water. In testing successive sections, test at least upper 10 feet of next preceding section so that each joint or pipe except upper most 10 feet of system has been submitted to a test of at least a 10 foot head of water. Water shall be kept in the system, or in portion under test, for at least 15 minutes before inspection starts. System shall then be tight at all joints.
2. For an air test, an air pressure of 5 psig gauge shall be maintained for at least 15 minutes without leakage. A force pump and mercury column gauge shall be used for the air test.
3. After installing all fixtures and equipment, open water supply so that all p-traps can be observed. For 15 minutes of operation, all p-traps shall be inspected for leaks and any leaks found shall be corrected.
4. Final Tests: Either one of the following tests may be used.
- a. Smoke Test: After fixtures are permanently connected and traps are filled with water, fill entire drainage and vent systems with

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-20

smoke under pressure of 1 inch of water with a smoke machine.

Chemical smoke is prohibited.

- b. Peppermint Test: Introduce 2 ounces of peppermint into each line or stack.

3.6 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
- B. Components provided under this section of the specification shall be tested as part of a larger system.

3.7 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for 4hours to instruct each VA personnel responsible in operation and maintenance of the system.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

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Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-15

SECTION 22 14 00
FACILITY STORM DRAINAGE

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section describes the requirements for storm drainage systems, including piping and all necessary accessories as designated in this section.
- B. A complete listing of all acronyms and abbreviations are included in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.
- D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
- E. Section 07 84 00, FIRESTOPPING: Penetrations in rated enclosures.
- F. Section 07 92 00, JOINT SEALANTS.
- G. Section 09 91 00, PAINTING: Preparation and finish painting and identification of piping systems.
- I. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING: Pipe Hangers and Supports, Materials Identification.
- J. Section 22 07 11, PLUMBING INSULATION.
- K. SECTION 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Mechanical Engineers (ASME):
 - A112.6.4-2003 (R2012) ..Roof, Deck, and Balcony Drains
 - A13.1-2007 (R2013).....Scheme for Identification of Piping Systems
 - B1.20.1-2013.....Pipe Threads, General Purpose, Inch
 - B16.3-2011.....Malleable Iron Threaded Fittings: Classes 150 and 300
 - B16.9-2012.....Factory-Made Wrought Buttwelding Fittings
 - B16.11-2011.....Forged Fittings, Socket-Welding and Threaded
 - B16.12-2009 (R2014).....Cast Iron Threaded Drainage Fittings

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-15

- B16.15-2013.....Cast Copper Alloy Threaded Fittings: Classes
125 and 250
- B16.18-2012.....Cast Copper Alloy Solder-Joint Pressure
Fittings
- B16.22-2013.....Wrought Copper and Copper Alloy Solder-Joint
Pressure Fittings
- B16.23-2011.....Cast Copper Alloy Solder Joint Drainage
Fittings - DWV
- B16.29-2012.....Wrought Copper and Wrought Copper Alloy Solder-
Joint Drainage Fittings - DWV
- C. American Society of Sanitary Engineering (ASSE)
1079-2012.....Performance Requirements for Dielectric Pipe
Unions
- D. American Society for Testing and Materials (ASTM):
- A47/A47M-1999 (R2014)...Standard Specification for Ferritic Malleable
Iron Castings
- A53/A53M-2012.....Standard Specification for Pipe, Steel, Black
And Hot-Dipped, Zinc-coated Welded and Seamless
- A74-2013a.....Standard Specification for Cast Iron Soil Pipe
and Fittings
- A183-2014.....Standard Specification for Carbon Steel Track
Bolts and Nuts
- A312/A312M-2015.....Standard Specification for Seamless, Welded,
and Heavily Cold Worked Austenitic Stainless
Steel Pipes
- A536-1984 (R2014).....Standard Specification for Ductile Iron
Castings
- A733-2013.....Standard Specification for Welded and Seamless
Carbon Steel and Austenitic Stainless Steel
Pipe Nipples
- A888-2013a.....Standard Specification for Hubless Cast Iron
Soil Pipe and Fittings for Sanitary and Storm
Drain, Waste, and Vent Piping Applications
- B32-2008 (R2014).....Standard Specification for Solder Metal

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-15

B61-2008 (R2013).....Standard Specification for Steam or Valve
Bronze Castings
B62-2009.....Standard Specification for Composition Bronze
or Ounce Metal Castings
B75/B75M-2011.....Standard Specification for Seamless Copper Tube
B88-2014.....Standard Specification for Seamless Copper
Water Tube
B306-2013.....Standard Specification for Copper Drainage Tube
(DWV)
B584-2014.....Standard Specification for Copper Alloy Sand
Castings for General Applications
B687-1999 (R2011).....Standard Specification for Brass, Copper, and
Chromium-Plated Pipe Nipples
B828-2002 (R2010).....Standard Practice for Making Capillary Joints
by Soldering of Copper and Copper Alloy Tube
and Fittings
B813-2010.....Standard Specification for Liquid and Paste
Fluxes for Soldering of Copper and Copper Alloy
Tube
C564-2014.....Standard Specification for Rubber Gaskets for
Cast Iron Soil Pipe and Fittings
C1173-2010 (R2014).....Standard Specification for Flexible Transition
Couplings for Underground Piping Systems
D1785-2012.....Standard Specification for Poly(Vinyl Chloride)
(PVC) Plastic Pipe, Schedules 40, 80 and 120
D2000-2012.....Standard Classification System for Rubber
Products in Automotive Applications
D2321-2014e1.....Standard Practice for Underground Installation
of Thermoplastic Pipe for Sewers and Other
Gravity-Flow Applications
D2564-2012.....Standard Specification for Solvent Cements for
Poly (Vinyl Chloride) (PVC) Plastic Piping
Systems

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-15

- D2665-2014.....Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
- D2855-1996 (R2010).....Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings
- D4101-2014.....Standard Specification for Polypropylene Injection and Extrusion Materials
- D5926-2011.....Standard for Poly (Vinyl Chloride) (PVC) Gaskets for Drain, Waste, and Vent (DWV), Sewer, Sanitary, and Storm Plumbing Systems
- F477-2014.....Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
- F656-2010.....Standard Specification for Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
- F1545-2015.....Standard Specification for Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges
- E. American Welding Society (AWS):
- A5.8M/A5.8 AMD1-2011....Specification for Filler Metals for Brazing and Braze Welding
- F. Copper Development Association (CDA):
- A4015-2011.....Copper Tube Handbook
- G. Cast Iron Soil Pipe Institute (CISPI):
- 301-2012.....Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
- 310-2012.....Standard Specification for Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
- H. International Code Council (ICC):
- IPC-2012.....International Plumbing Code
- I. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS):

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-15

SP-72-2010a.....Ball Valves with Flanged or Butt-Welding Ends
for General Service

SP-110-2010.....Ball Valves Threaded, Socket-Welding, Solder
Joint, Grooved and Flared Ends

1.4 SUBMITTALS

- A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 22 14 00, FACILITY STORM DRAINAGE", with applicable paragraph identification.
- C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
 - 1. Pipe and Fittings.
 - 2. Specialty Pipe Fittings.
 - 3. Cleanouts.
 - 4. Roof Drains.
 - 5. Expansion Joints.
 - 6. Downspout Nozzles.
 - 7. Sleeve Flashing Devices.
- D. Detailed shop drawing of clamping device and extensions when required in connection with the waterproofing membrane.
- E. Completed System Readiness Checklist provided by the CxA and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
- F. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.5 QUALITY ASSURANCE

- A. Bio-Based Materials: For products designated by the USDA's Bio-Preferred Program, provide products that meet or exceed USDA recommendations for bio-based content, so long as products meet all

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-15

performance requirements in this specifications section. For more information regarding the product categories covered by the Bio-Preferred Program, visit <http://www.biopreferred.gov>.

1.6 AS-BUILT DOCUMENTATION

- A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be in electronic version on compact disc or DVD inserted into a three ring binder. All aspects of system operation and maintenance procedures, including piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices such as damper and door closure interlocks shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.
- C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them in Auto-CAD version 2010 provided on compact disc or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement.
- D. Certification documentation shall be provided to COR 10 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and certification that all results of tests were within limits specified.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-15

PART 2 - PRODUCTS

2.1 STORM WATER DRAIN PIPING

A. Cast Iron Storm Pipe and Fittings:

1. Cast iron storm pipe and fittings shall be used for the following applications:
 - a. Pipe buried in or in contact with earth.
 - b. Extension of pipe to a distance of approximately 5 feet outside of building walls.
 - c. Interior storm piping above grade.
 - d. All mechanical equipment rooms or other areas containing mechanical air handling equipment.
2. The cast iron storm pipe shall be bell and spigot, or hubless (plain end or no-hub) as required by selected jointing method.
3. The material for all pipe and fittings shall be cast iron soil pipe and fittings and shall conform to the requirements of CISPI 301, ASTM A888, or ASTM A74.
4. Joints for hubless pipe and fittings shall conform to the manufacturer's installation instructions. Couplings for hubless joints shall conform to CISPI 310. Joints for hub and spigot pipe shall be installed with compression gaskets conforming to the requirements of ASTM C564.

2.2 PUMPED DRAIN PIPING (NOT USED)

2.3 SPECIALTY PIPE FITTINGS

- A. Transition pipe couplings shall join piping with small differences in outside diameters or be of different materials. End connections shall be of the same size and compatible with the pipes being joined. The transition coupling shall be unshielded, elastomeric, sleeve type reducing or transition pattern conforming with ASTM C1173 and include shear ring and corrosion resistant metal tension band and tightening mechanism on each end. The transition coupling sleeve coupling shall be of the following material:
1. For cast iron soil pipes, the sleeve material shall be rubber conforming to ASTM C564.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-15

2. Dissimilar pipes, the sleeve material shall be PVC conforming to ASTM D5926, or other material compatible with the pipe materials being joined.
- B. Dielectric fittings shall conform to ASSE 1079 with a pressure rating of 150 psig 250 psig at a minimum temperature of 82 degrees C (180 degrees F). The end connection shall be solder joint copper alloy and threaded ferrous.
- C. Dielectric flanges shall conform to ASSE 1079 with a pressure rating of 150 psig. The flange shall be a factory fabricated, bolted, companion flange assembly. The end connection shall be threaded or solder-joint copper alloy and threaded ferrous.
- D. Dielectric flange insulating kits shall be of non-conducting materials for field assembly of companion flanges with a pressure rating of 150 psig. The gasket shall be neoprene or phenolic. The bolt sleeves shall be phenolic or polyethylene. The washers shall be phenolic with steel backing washers.
- E. Dielectric nipples shall be electroplated steel and shall conform with ASTM F1545 with a pressure ratings of 300 psig at 225 degrees F. The end connection shall be male threaded. The lining shall be inert and noncorrosive propylene. Bio-based materials shall be utilized when possible.

2.4 CLEANOUTS

- A. Cleanouts shall be the same size as the pipe, up to 4 inches; not less than 4 inches for larger pipe. Cleanouts shall be easily accessible and shall be gastight and watertight. A minimum clearance of 24 inches shall be provided for clearing a clogged storm sewer line.
- B. Floor cleanouts shall be gray iron housing with clamping device and round, secured, scoriated, gray iron cover conforming to ASME A112.36.2M. A gray iron ferrule with hubless, socket, inside caulk or spigot connection and counter sunk, taper-thread, brass or bronze closure plug shall be included. The frame and cover material and finish shall be nickel-bronze copper alloy with a square shape. The cleanout shall be vertically adjustable for a minimum of 2 inches. When a waterproof membrane is used in the floor system, clamping collars shall be provided on the cleanouts. Cleanouts shall consist of wye fittings

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-15

and eighth bends with brass or bronze screw plugs. Cleanouts in the resilient tile floors, quarry tile and ceramic tile floors shall be provided with square top covers recessed for tile insertion. In the carpeted areas, carpet cleanout markers shall be provided. Two way cleanouts shall be provided where indicated on the drawings and at each building exit. The loading classification for cleanouts in sidewalk areas or subject to vehicular traffic shall be heavy duty.

- C. Cleanouts shall be provided at or near the base of the vertical stacks with the cleanout plug located approximately 24 inches above the floor. The cleanouts shall be extended to the wall access cover. Cleanout shall consist of sanitary tees. Nickel bronze square frame and stainless steel cover with minimum opening of 6 inch by 6 inch shall be provided at each wall cleanout.
- D. In horizontal runs above grade, cleanouts shall consist of cast brass tapered screw plug in fitting or caulked/no hub cast iron ferrule. Plain end (no-hub) piping in interstitial space or above ceiling may use plain end (no-hub) blind plug and clamp.

2.5 ROOF DRAINS AND CONNECTIONS

- A. Roof Drains: Roof Drains (RD) shall be cast iron with clamping device for making watertight connection and shall conform with ASME A112.6.4. Free openings through strainer shall be twice area of drain outlet. For roof drains not installed in connection with a waterproof membrane, a soft copper membrane shall be provided 12 inches in diameter greater than outside diameter of drain collar. An integral gravel stop shall be provided for drains installed on roofs having built up roofing covered with gravel or slag. Integral no-hub, soil pipe gasket or threaded outlet connection shall be provided.
 - 1. Flat Roofs: The roof drain shall have a beehive or dome shaped strainer with integral flange not less than 12 inches in diameter. For an insulated roof, a roof drain with an adjustable drainage collar shall be provided, which can be raised or lowered to meet required insulation heights, sump receiver and deck clamp. The bottom section shall serve as roof drain during construction before insulation is installed.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-15

2. Protective Roof Membrane Insulation Assembly: The roof drain shall have a perforated stainless steel extension filter, non-puncturing clamp ring, large sump with extra wide roof flange and deck clamp.
 - a. Non pedestrian Roofs: The roof drain shall have large polypropylene or aluminum locking dome.
 - b. Pedestrian Roof: The roof drain shall have a bronze promenade top 14 inches square, set in square secured frame support collar.
6. Roof Drains, Overflow or Secondary (Emergency): Roof Drains identified as overflow or secondary (emergency) drains shall have a 2 inch water dam integral to the drain body.
7. Roof drains in areas subject to freezing shall have heat tape and shall be insulated.
- B. Expansion Joints: Expansions joints shall be heavy cast iron with cast brass or PVC expansion sleeve having smooth bearing surface working freely against a packing ring held in place and under pressure of a bolted gland ring, forming a water and air tight flexible joint. Asbestos packing is prohibited.
- C. Interior Downspouts: An expansion joint shall be provided, specified above, at top of run on straight, vertical runs of downspout piping 40 feet long or greater.
- D. Downspout Nozzle: The downspout nozzle fitting shall be of brass, unfinished, with internal pipe thread for connection to downspout.

2.6 WATERPROOFING

- A. A sleeve flashing device shall be provided at points where pipes pass through membrane waterproofed floors or walls. The sleeve flashing device shall be manufactured, cast iron fitting with clamping device that forms a sleeve for the pipe floor penetration of the floor membrane. A galvanized steel pipe extension shall be included in the top of the fitting that will extend 2 inches above finished floor and galvanized steel pipe extension in the bottom of the fitting that will extend through the floor slab. A waterproofed caulked joint shall be provided at the top hub.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-15

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

- A. The pipe installation shall comply with the requirements of the IPC and these specifications.
- B. Branch piping shall be installed from the piping system and connect to all drains and outlets.
- C. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe, except for glass, shall be reamed to remove burrs and a clean smooth finish restored to full pipe inside diameter.
- D. All pipe runs shall be laid out to avoid interference with other work/trades.
- E. The piping shall be installed above accessible ceilings to allow for ceiling panel removal.
- F. Unless otherwise stated on the documents, minimum horizontal slope shall be one inch for every 8 feet (1 percent slope) of pipe length.
- G. The piping shall be installed free of sags and bends.
- H. Seismic restraint shall be installed where required by code.
- I. Changes in direction for storm drainage piping shall be made using appropriate branches, bends and long sweep bends. Sanitary tees and short sweep $\frac{1}{4}$ bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Long turn double wye branch and $\frac{1}{8}$ bend fittings shall be used if two drains are installed back to back or side by side with common drain pipe. Do not change direction of flow more than 90 degrees. Proper size of standard increaser and reducers shall be used if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- J. Buried storm drainage piping shall be laid beginning at the low point of each system. Piping shall be installed true to grades and alignment indicated with unbroken continuity of invert. Hub ends shall be placed upstream. Required gaskets shall be installed according to manufacturer's written instruction for use of lubricants, cements, and other installation requirements. Bio-based materials shall be utilized when possible.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-15

- K. Cast iron piping shall be installed according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings"
- L. Aboveground copper tubing shall be installed according to CDA A4015.
- M. Aboveground PVC piping shall be installed according to ASTM D2665.
Underground PVC piping shall be installed according to ASTM D2321.

3.2 JOINT CONSTRUCTION

- A. Hub and spigot, cast iron piping with gasket joints shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- B. Hub and spigot, cast iron piping with calked joints shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.
- C. Hubless, cast iron piping shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless piping coupling joints.
- D. For threaded joints, thread pipe with tapered pipe threads according to ASME B1.20.1. The threads shall be cut full and clean using sharp disc cutters. Threaded pipe ends shall be reamed to remove burrs and restored to full pipe inside diameter. Pipe fittings and valves shall be joined as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is required by the pipe service
 - 2. Pipe sections with damaged threads shall be replaced with new undamaged sections of pipe at no additional time or cost to Government.

3.3 SPECIALTY PIPE FITTINGS

- A. Transition coupling shall be installed at pipe joints with small differences in pipe outside diameters.
- B. Dielectric fittings shall be installed at connections of dissimilar metal piping and tubing.

3.4 PIPE HANGERS, SUPPORTS AND ACCESSORIES

- A. All piping shall be supported according to the IPC, Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, and these specifications.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-15

- B. Hangers, supports, rods, inserts and accessories used for Pipe supports shall be shop coated with zinc Chromate primer paint. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.
- C. Horizontal piping and tubing shall be supported within 300 mm (12 inches) of each fitting or coupling.
- D. Horizontal cast iron piping shall be supported with the following maximum horizontal spacing and minimum hanger rod diameters:
 - 1. NPS 1-1/2 to NPS 2 : 60 inches with 3/8 inch rod.
 - 2. NPS 3 : 60 inches with 1/2 inch rod.
 - 3. NPS 4 to NPS 5 : 60 inches with 5/8 inch rod.
 - 4. NPS 6 to NPS 8 : 60 inches with 3/4 inch rod.
- E. Vertical piping and tubing shall be supported at the base, at each floor, and at intervals no greater than 15 feet.
- G. In addition to the requirements in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, floor, wall and ceiling plates shall have the following characteristics:
 - 1. Solid or split unplated cast iron.
 - 2. All plates shall be provided with set screws.
 - 3. Height adjustable clevis type pipe hangers.
 - 4. Adjustable Floor Rests and Base Flanges shall be steel.
 - 5. Hanger Rods shall be low carbon steel, fully threaded or threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.
 - 6. Riser Clamps shall be malleable iron or steel.
 - 7. Roller shall be cast iron.
 - 8. Hangers and supports utilized with insulated pipe and tubing shall have 180 degree (minimum) metal protection shield centered on and welded to the hanger and support. The shield shall be 4 inches in length and be 16 gage steel. The shield shall be sized for the insulation.
- H. Miscellaneous materials shall be provided as specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories. If the vertical distance exceeds 20 feet for cast iron pipe additional support shall be provided in the

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-15

center of that span. All necessary auxiliary steel shall be provided to provide that support.

- I. Cast escutcheon with set screw shall be installed at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.
- J. Penetrations:
 - 1. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, a fire stop shall be installed that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING. Clearances between raceways and openings shall be completely filled and sealed with the fire stopping materials.
 - 2. Water proofing: At floor penetrations, Clearances around the pipe shall be completely sealed and made watertight with sealant as specified in Section 07 92 00, JOINT SEALANTS. Bio-based materials shall be utilized when possible.

3.5 INSULATION

- A. Insulate horizontal sections and 2 feet past changes of direction to vertical sections for interior section of roof drains. Install insulation in accordance with the requirements of Section 22 07 11, PLUMBING INSULATION.

3.6 TESTS

- A. Storm sewer system shall be tested either in its entirety or in sections.
- B. Storm Water Drain tests shall be conducted before trenches are backfilled or fixtures are connected. A water test or air test shall be conducted, as directed.
 - 1. If entire system is tested with water, tightly close all openings in pipes except the highest opening, and fill system with water to point of overflow. If system is tested in sections, tightly plug each opening except highest opening of section under test, fill each section with water and test with at least a 10 foot head of water. In testing successive sections, test at least upper 10 feet of next preceding section so that each joint or pipe except upper most 10 feet of system has been submitted to a test of at least a 10 foot

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-15

- head of water. Water shall be kept in the system, or in portion under test, for at least 15 minutes before inspection starts. System shall then be tight at all joints.
2. For an air test, an air pressure of 5 psig gage shall be maintained for at least 15 minutes without leakage. A force pump and mercury column gage shall be used for the test.
 3. Final Tests: While either one of the following tests may be used, Contractor shall check with VA as to which test will be performed.
 - a. Smoke Test: After fixtures are permanently connected and traps are filled with water, fill entire drainage and vent systems with smoke under pressure of 1 inch of water with a smoke machine.
Chemical smoke is prohibited.
 - b. Peppermint Test: Introduce .06 liters (2 ounces) of peppermint into each line or stack.
 - C. COR shall witness all tests. Contractor shall coordinate schedules with the COR and CxA. Contractor shall provide a minimum of 10 working days prior to flushing, disinfection/sterilization, startup, and testing.

3.7 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
- B. Components provided under this section of the specification will be tested as part of a larger system.

3.8 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for four hours to instruct VA Personnel in operation and maintenance of the system.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

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Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

SECTION 22 40 00
PLUMBING FIXTURES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Plumbing fixtures, associated trim and fittings necessary to make a complete installation from wall or floor connections to rough piping, and certain accessories.
- B. A complete listing of all acronyms and abbreviations are included in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.
- D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
- E. Section 07 92 00, JOINT SEALANTS: Sealing between fixtures and other finish surfaces.
- F. Section 08 31 13, ACCESS DOORS AND FRAMES: Flush panel access doors.
- G. Section 10 21 13, TOILET COMPARTMENTS: Through bolts.
- H. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
- I. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS: Requirements for commissioning, systems readiness checklist, and training.
- J. Section 22 13 00, FACILITY SANITARY AND VENT PIPING.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. The American Society of Mechanical Engineers (ASME):
 - A112.6.1M-1997 (R2012)..Supports for Off-the-Floor Plumbing Fixtures
for Public Use
 - A112.19.1-2013.....Enameled Cast Iron and Enameled Steel Plumbing
Fixtures
 - A112.19.2-2013.....Ceramic Plumbing Fixtures
 - A112.19.3-2008.....Stainless Steel Plumbing Fixtures

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

C. American Society for Testing and Materials (ASTM):

A276-2013a.....Standard Specification for Stainless Steel Bars
and Shapes

B584-2008.....Standard Specification for Copper Alloy Sand
Castings for General Applications

D. CSA Group:

B45.4-2008 (R2013).....Stainless Steel Plumbing Fixtures

E. National Association of Architectural Metal Manufacturers (NAAMM):

AMP 500-2006.....Metal Finishes Manual

F. American Society of Sanitary Engineering (ASSE):

1016-2011.....Automatic Compensating Valves for Individual
Showers and Tub/Shower Combinations

G. NSF International (NSF):

14-2013.....Plastics Piping System Components and Related
Materials

61-2013.....Drinking Water System Components - Health
Effects

372-2011.....Drinking Water System Components - Lead Content

H. American with Disabilities Act (A.D.A)

I. International Code Council (ICC):

IPC-2015.....International Plumbing Code

1.4 SUBMITTALS

A. Submittals, including number of required copies, will be submitted in
accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND
SAMPLES.

B. Information and material submitted under this section will be marked
"SUBMITTED UNDER SECTION 22 40 00, PLUMBING FIXTURES", with applicable
paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and
optional features and accessories. Include dimensions, weights,
materials, applications, standard compliance, model numbers, size,
connections, and capacity.

D. Operating Instructions: Comply with requirements in Section 01 00 00,
GENERAL REQUIREMENTS.

E. Completed System Readiness Checklist provided by the CxA and completed
by the Contractor, signed by a qualified technician and dated on the
Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

- F. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.5 QUALITY ASSURANCE

- A. Bio-Based Materials: For products designated by the USDA's Bio-Preferred Program, provide products that meet or exceed USDA recommendations for bio-based content, so long as products meet all performance requirements in this specifications section. For more information regarding the product categories covered by the Bio-Preferred Program, visit <http://www.biopREFERRED.gov>.

1.6 AS-BUILT DOCUMENTATION

- A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions will be in electronic version on compact disc or DVD inserted into a three ring binder. All aspects of system operation and maintenance procedures, including piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation will be included in the operation and maintenance manual. The operations and maintenance manual will include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices such as damper and door closure interlocks will be included. A List of recommended spare parts (manufacturer, model number, and quantity) will be furnished. Information explaining any special knowledge or tools the owner will be required to employ will be inserted into the As-Built documentation.
- C. The installing contractor will maintain as-built drawings of each completed phase for verification; and, will provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them in AutoCAD version 2010 provided on compact disk or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it will not

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

be deemed a conflict of interest or breach of the 'third party testing company' requirement.

- D. Certification documentation will be provided to COR 10 working days prior to submitting the request for final inspection. The documentation will include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and certification that all results of tests were within limits specified.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Material or equipment containing a weighted average of greater than 0.25 percent lead is prohibited in any potable water system intended for human consumption, and will be certified in accordance with NSF 61 or NSF 372. Endpoint devices used to dispense water for drinking will meet the requirements of NSF 61.
- B. Plastic pipe, fittings, and solvent cement will meet NSF 14 and will be NSF listed for the service intended.

2.2 STAINLESS STEEL

- A. Corrosion-resistant Steel (CRS):
1. Plate, Sheet and Strip: CRS flat products will conform to chemical composition requirements of any 300 series steel specified in ASTM A276.
 2. Finish: Exposed surfaces will have standard polish (ground and polished) equal to NAAMM finish Number 4.
- B. Die-cast zinc alloy products are prohibited.

2.3 STOPS

- A. Provide lock-shield loose key or screw driver pattern angle stops, straight stops or stops integral with faucet, with each compression type faucet whether specifically called for or not, including sinks in solid-surface, wood and metal casework, laboratory furniture and pharmacy furniture. Locate stops centrally above or below fixture in accessible location.
- B. Furnish keys for lock shield stops to the COR.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

- C. Supply from stops not integral with faucet will be chrome plated copper flexible tubing or flexible stainless steel with inner core of non-toxic polymer.
- D. Supply pipe from wall to valve stop will be rigid threaded IPS copper alloy pipe, i.e. red brass pipe nipple, chrome plated where exposed.
- E. Mental Health Area: Provide stainless steel drain guard for all lavatories not installed in casework.

2.4 ESCUTCHEONS

- A. Heavy type, chrome plated, with set screws. Provide for piping serving plumbing fixtures and at each wall, ceiling and floor penetrations in exposed finished locations and within cabinets and millwork.

2.5 LAMINAR FLOW CONTROL DEVICE

- A. Smooth, bright stainless steel or satin finish, chrome plated metal laminar flow device will provide non-aeration, clear, coherent laminar flow that will not splash in basin. Device will also have a flow control restrictor and have vandal resistant housing. **Aerators are prohibited.**
- B. Flow Control Restrictor:
 - 1. Capable of restricting flow from 0.5 gpm to 1.5 gpm for lavatories; 2.0 gpm to 2.2 gpm for sinks P-505 through P-520, P-524 and P-528; and 2.75 gpm to 3.0 gpm for dietary food preparation and rinse sinks or as specified.
 - 2. Compensates for pressure fluctuation maintaining flow rate specified above within 10 percent between 25 psig and 80 psig.
 - 3. Operates by expansion and contraction, eliminates mineral/sediment build-up with self-cleaning action, and is capable of easy manual cleaning.

2.6 CARRIERS

- A. ASME A112.6.1M, with adjustable gasket faceplate chair carriers for wall hung closets with auxiliary anchor foot assembly, hanger rod support feet, and rear anchor tie down.
- B. ASME A112.6.1M, lavatory, / chair carrier for thin wall construction concealed arm support steel plate as detailed on drawing . All lavatory chair carriers will be capable of supporting the lavatory with a 250-pound vertical load applied at the front of the fixture.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

2.7 WATER CLOSETS (NOT USED)

2.8 URINALS (NOT USED)

2.9 BATHTUBS (NOT USED)

2.10 LAVATORIES (NOT USED)

2.11 SINKS AND LAUNDRY TUBS

A. Dimensions for sinks and laundry tubs are specified, length by width (distance from wall) and depth.

B. (P-502) Service Sink (Corner, Floor Mounted) stain resistant terrazzo, 28 inches by 28 inches by 12 inches with 6 inches drop front. Terrazzo, composed of marble chips and white Portland cement, will develop compressive strength of 3000 psig seven days after casting. Provide extruded aluminum cap on front side.

1. Faucet: Solid brass construction, 2.5 gpm combination faucet with replaceable Monel seat, removable replacement unit containing all parts subject to wear, integral check/stops, mounted on wall above sink. Spout will have a pail hook, 3/4 inch hose coupling threads, vacuum breaker, and top or bottom brace to wall. Four-arm handles on faucets will be cast, formed, or drop forged copper alloy. Escutcheons will be either forged copper alloy or CRS. Exposed metal parts, including exposed part under valve handle when in open position, will have a smooth bright finish. Provide 36 inches hose with wall hook. Centerline of rough in is 48 inches above finished floor.

2. Drain: 3 inches cast brass drain with nickel bronze strainer.

3. Trap: P-trap, drain through floor.

2.12 DISPENSER, DRINKING WATER (NOT USED)

2.13 SHOWER BATH FIXTURE (NOT USED)

2.14 EMERGENCY FIXTURES (NOT USED)

2.15 HYDRANT, HOSE BIBB AND MISCELLANEOUS DEVICES (NOT USED)

2.16 MENTAL HEALTH PLUMBING FIXTURES (NOT USED)

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fixture Setting: Opening between fixture and floor and wall finish will be sealed as specified under Section 07 92 00, JOINT SEALANTS. Bio-based materials will be utilized when possible.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

- B. Supports and Fastening: Secure all fixtures, equipment and trimmings to partitions, walls and related finish surfaces. Exposed heads of bolts and nuts in finished rooms will be hexagonal, polished chrome plated brass with rounded tops.
- C. Through Bolts: For free standing marble and metal stud partitions refer to Section 10 21 13, TOILET COMPARTMENTS.
- D. Toggle Bolts: For hollow masonry units, finished or unfinished.
- E. Expansion Bolts: For brick or concrete or other solid masonry. Will be 1/4 inch diameter bolts, and to extend at least 3 inches into masonry and be fitted with loose tubing or sleeves extending into masonry. Wood plugs, fiber plugs, lead or other soft metal shields are prohibited.
- F. Power Set Fasteners: May be used for concrete walls, will be 1/4 inch threaded studs, and will extend at least 1 1/4 inches into wall.
- G. Tightly cover and protect fixtures and equipment against dirt, water and chemical or mechanical injury.
- H. If an installation is unsatisfactory to the COR, the Contractor will correct the installation at no cost or additional time to the Government.

3.2 CLEANING

- A. At completion of all work, fixtures, exposed materials and equipment will be thoroughly cleaned.

3.3 WATERLESS URINAL (NOT USED)

- A. Manufacturer will provide an operating manual and onsite training for the proper care and maintenance of the urinals.

3.4 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
- B. Components provided under this section of the specification will be tested as part of a larger system.

3.5 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for fourhours to instruct VA Personnel in operation and maintenance of the system.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

- - - E N D - - -

DIVISION 23

HEATING, VENTILATING, AND AIR
CONDITIONING (HVAC)

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

SECTION 23 05 11
COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements of this Section apply to all sections of Division 23.

B. Definitions:

1. Exposed: Piping, ductwork, and equipment exposed to view in finished rooms.
2. Exterior: Piping, ductwork, and equipment exposed to weather be it temperature, humidity, precipitation, wind, or solar radiation.

C. Abbreviations/Acronyms:

1. ac: Alternating Current
2. AC: Air Conditioning
3. ACU: Air Conditioning Unit
4. ACR: Air Conditioning and Refrigeration
5. AI: Analog Input
6. AISI: American Iron and Steel Institute
7. AO: Analog Output
8. ASJ: All Service Jacket
9. AWG: American Wire Gauge
10. BACnet: Building Automation and Control Networking Protocol
11. BAg: Silver-Copper-Zinc Brazing Alloy
12. BAS: Building Automation System
13. BCuP: Silver-Copper-Phosphorus Brazing Alloy
14. bhp: Brake Horsepower
15. Btu: British Thermal Unit
16. Btu/h: British Thermal Unit Per Hour
17. CDA: Copper Development Association
18. C: Celsius
19. CD: Compact Disk
20. CFM: Cubic Foot Per Minute
21. CH: Chilled Water Supply
22. CHR: Chilled Water Return
23. CLR: Color
24. COR: Contracting Officer's Representative
25. CPD: Condensate Pump Discharge

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

- 26. CPM: Cycles Per Minute
- 27. CPVC: Chlorinated Polyvinyl Chloride
- 28. CRS: Corrosion Resistant Steel
- 29. CTPD: Condensate Transfer Pump Discharge
- 30. CTPS: Condensate Transfer Pump Suction
- 31. CW: Cold Water
- 32. CWP: Cold Working Pressure
- 33. CxA: Commissioning Agent
- 34. dB: Decibels
- 35. dB(A): Decibels (A weighted)
- 36. DDC: Direct Digital Control
- 37. DI: Digital Input
- 38. DO: Digital Output
- 39. DVD: Digital Video Disc
- 40. DN: Diameter Nominal
- 41. DWV: Drainage, Waste and Vent
- 42. EPDM: Ethylene Propylene Diene Monomer
- 43. EPT: Ethylene Propylene Terpolymer
- 44. ETO: Ethylene Oxide
- 45. F: Fahrenheit
- 46. FAR: Federal Acquisition Regulations
- 47. FD: Floor Drain
- 48. FED: Federal
- 49. FG: Fiberglass
- 50. FGR: Flue Gas Recirculation
- 51. FOS: Fuel Oil Supply
- 52. FOR: Fuel Oil Return
- 53. FSK: Foil-Scrim-Kraft facing
- 54. GC: Chilled Glycol Water Supply
- 55. GCR: Chilled Glycol Water Return
- 56. GH: Hot Glycol Water Heating Supply
- 57. GHR: Hot Glycol Water Heating Return
- 58. gpm: Gallons Per Minute
- 59. HDPE: High Density Polyethylene
- 60. Hg: Mercury
- 61. HOA: Hands-Off-Automatic

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

- 62. hp: Horsepower
- 63. HPS: High Pressure Steam (414 kPa (60 psig) and above)
- 64. HPR: High Pressure Steam Condensate Return
- 65. HW: Hot Water
- 66. HWH: Hot Water Heating Supply
- 67. HWHR: Hot Water Heating Return
- 68. Hz: Hertz
- 69. ID: Inside Diameter
- 70. IPS: Iron Pipe Size
- 71. kg: Kilogram
- 72. klb: 1000 lb
- 73. kPa: Kilopascal
- 74. lb: Pound
- 75. lb/hr: Pounds Per Hour
- 76. LPS: Low Pressure Steam (103 kPa (15 psig) and below)
- 77. LPR: Low Pressure Steam Condensate Gravity Return
- 78. MAWP: Maximum Allowable Working Pressure
- 79. MAX: Maximum
- 80. MBtu/h: 1000 Btu/h
- 81. MBtu: 1000 Btu
- 82. MED: Medical
- 83. m: Meter
- 84. MFG: Manufacturer
- 85. mg: Milligram
- 86. mg/L: Milligrams Per Liter
- 87. MIN: Minimum
- 88. MJ: Megajoules
- 89. ml: Milliliter
- 90. mm: Millimeter
- MPS: Medium Pressure Steam (110 kPa (16 psig) through 414 kPa (60 psig))
- 91. MW: Megawatt
- 92. NC: Normally Closed
- 93. Nm: Newton Meter
- 94. NO: Normally Open
- 95. NOx: Nitrous Oxide

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

- 96. NPT: National Pipe Thread
- 97. NPS: Nominal Pipe Size
- 98. OD: Outside Diameter
- 99. OSD: Open Sight Drain
- 100. OS&Y: Outside Stem and Yoke
- 101. PC: Pumped Condensate
- 102. PID: Proportional-Integral-Differential
- 103. PLC: Programmable Logic Controllers
- 104. PP: Polypropylene
- 105. PPE: Personal Protection Equipment
- 106. ppb: Parts Per Billion
- 107. ppm: Parts Per Million
- 108. PRV: Pressure Reducing Valve \
- 109. PSIA: Pounds Per Square Inch Absolute
- 110. psig: Pounds Per Square Inch Gauge
- 111. PTFE: Polytetrafluoroethylene
- 112. PVC: Polyvinyl Chloride
- 113. rad: Radians
- 114. RH: Relative Humidity
- 115. rms: Root Mean Square
- 116. RPM: Revolutions Per Minute
- 117. RS: Refrigerant Suction
- 118. RTD: Resistance Temperature Detectors
- 119. RTRF: Reinforced Thermosetting Resin Fittings
- 120. RTRP: Reinforced Thermosetting Resin Pipe
- 121. SCFM: Standard Cubic Feet Per Minute
- 122. SPEC: Specification
- 123. SPS: Sterile Processing Services
- 124. STD: Standard
- 125. SDR: Standard Dimension Ratio
- 126. SUS: Saybolt Universal Second
- 127. SW: Soft water
- 128. SWP: Steam Working Pressure
- 129. TAB: Testing, Adjusting, and Balancing
- 130. TDH: Total Dynamic Head
- 131. TEFC: Totally Enclosed Fan-Cooled

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

- 132. TFE: Tetrafluoroethylene
- 133. THERM: 100,000 Btu
- 134. THHN: Thermoplastic High-Heat Resistant Nylon Coated Wire
- 135. THWN: Thermoplastic Heat & Water-Resistant Nylon Coated Wire
- 136. T/P: Temperature and Pressure
- 137. USDA: U.S. Department of Agriculture
- 138. V: Volt
- 139. VAC: Vacuum
- 140. VA: Veterans Administration
- 141. VAC: Voltage in Alternating Current
- 142. VA CFM: VA Construction & Facilities Management
- 143. VA CFM CSS: VA Construction & Facilities Management, Consulting Support Service
- 144. VAMC: Veterans Administration Medical Center
- 145. VHA OCAMES: Veterans Health Administration - Office of Capital Asset Management Engineering and Support
- 146. VR: Vacuum condensate return
- 147. WCB: Wrought Carbon Steel, Grade B
- 148. WG: Water Gauge or Water Column
- 149. WOG: Water, Oil, Gas

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.
- D. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.
- E. Section 05 31 00, STEEL DECKING.
- F. Section 07 84 00, FIRESTOPPING.
- G. Section 07 92 00, JOINT SEALANTS.
- H. Section 09 91 00, PAINTING.
- I. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION.
- J. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- K. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
- L. Section 23 07 11, HVAC AND BOILER PLANT INSULATION.
- M. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

- N. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
O. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
P. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.

- B. Air Movement and Control Association (AMCA):

410-1996.....Recommended Safety Practices for Users and
Installers of Industrial and Commercial Fans

- C. American Society of Mechanical Engineers (ASME):

B31.1-2018.....Power Piping

B31.9-2014.....Building Services Piping

ASME Boiler and Pressure Vessel Code:

BPVC Section IX-2019 Welding, Brazing, and Fusing Qualifications

- D. American Society for Testing and Materials (ASTM):

A36/A36M-2014.....Standard Specification for Carbon Structural
Steel

A575-1996(R2018).....Standard Specification for Steel Bars, Carbon,
Merchant Quality, M-Grades

- E. Manufacturers Standardization Society (MSS) of the Valve and Fittings Industry, Inc.:

SP-58-2018.....Pipe Hangers and Supports-Materials, Design,
Manufacture, Selection, Application, and
Installation

SP-127-2014a.....Bracing for Piping Systems: Seismic-Wind-
Dynamic Design, Selection, and Application

- F. Military Specifications (MIL):

MIL-P-21035B-2013.....Paint High Zinc Dust Content, Galvanizing
Repair (Metric)

- G. National Fire Protection Association (NFPA):

70-2017.....National Electrical Code (NEC)

101-2018.....Life Safety Code

- H. Department of Veterans Affairs (VA):

PG-18-10-2016.....Physical Security and Resiliency Design Manual

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

1.4 SUBMITTALS

- A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 05 11, COMMON WORK RESULTS FOR HVAC", with applicable paragraph identification.
- C. If the project is phased submit complete phasing plan/schedule with manpower levels prior to commencing work. The phasing plan shall be detailed enough to provide milestones in the process that can be verified.
- D. Contractor shall make all necessary field measurements and investigations to assure that the equipment and assemblies will meet contract requirements, and all equipment that requires regular maintenance, calibration, etc are accessible from the floor or permanent work platform. It is the Contractor's responsibility to ensure all submittals meet the VA specifications and requirements and it is assumed by the VA that all submittals do meet the VA specifications unless the Contractor has requested a variance in writing and approved by COR prior to the submittal. If at any time during the project it is found that any item does not meet the VA specifications and there was no variance approval the Contractor shall correct at no additional cost or time to the Government even if a submittal was approved.
- E. If equipment is submitted which differs in arrangement from that shown, provide documentation proving equivalent performance, design standards and drawings that show the rearrangement of all associated systems. Additionally, any impacts on ancillary equipment or services such as foundations, piping, and electrical shall be the Contractor's responsibility to design, supply, and install at no additional cost or time to the Government. VA approval will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract.
- F. Prior to submitting shop drawings for approval, Contractor shall certify in writing that manufacturers of all major items of equipment

have each reviewed contract documents, and have jointly coordinated and
Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

properly integrated their equipment and controls to provide a complete and efficient installation.

- G. Submittals and shop drawings for interdependent items, containing applicable descriptive information, shall be furnished together. Coordinate and properly integrate materials and equipment to provide a completely compatible and efficient installation.

H. Coordination/Shop Drawings:

1. Submit complete consolidated and coordinated shop drawings for all new systems, and for existing systems that are in the same areas.
2. The coordination/shop drawings shall include plan views, elevations and sections of all systems and shall be on a scale of not less than 1:32 (3/8-inch equal to one foot). Clearly identify and dimension the proposed locations of the principal items of equipment. The drawings shall clearly show locations and adequate clearance for all equipment, piping, valves, control panels and other items. Show the access means for all items requiring access for operations and maintenance. Provide detailed coordination/shop drawings of all piping and duct systems. The drawings should include all lockout/tagout points for all energy/hazard sources for each piece of equipment. Coordinate lockout/tagout procedures and practices with local VA requirements.
3. Do not install equipment foundations, equipment or piping until coordination/shop drawings have been approved.
4. In addition, for HVAC systems, provide details of the following:
 - a. Mechanical equipment rooms.
 - b. Hangers, inserts, supports, and bracing.
 - c. Pipe sleeves.
 - d. Duct or equipment penetrations of floors, walls, ceilings, or roofs.

- I. Manufacturer's Literature and Data: Include full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity. Submit under the pertinent section rather than under this section.

1. Submit belt drive with the driven equipment. Submit selection data for specific drives when requested by the COR.

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

2. Submit electric motor data and variable speed drive data with the driven equipment.
 3. Equipment and materials identification.
 4. Fire-stopping materials.
 5. Hangers, inserts, supports and bracing. Provide complete stress analysis for variable spring and constant support hangers.
 6. Wall, floor, and ceiling plates.
- J. Rigging Plan: Provide documentation of the capacity and weight of the rigging and equipment intended to be used. The plan shall include the path of travel of the load, the staging area and intended access, and qualifications of the operator and signal person.
- K. HVAC Maintenance Data and Operating Instructions:
1. Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS, Article, INSTRUCTIONS, for systems and equipment.
 2. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
 - a. Include complete list indicating all components of the systems.
 - b. Include complete diagrams of the internal wiring for each item of equipment.
 - c. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.
 3. Provide a listing of recommended replacement parts for keeping in stock supply, including sources of supply, for equipment. Include in the listing belts for equipment: Belt manufacturer, model number, size and style, and distinguished whether of multiple belt sets.
- L. Provide copies of approved HVAC equipment submittals to the TAB and Commissioning Subcontractor.
- M. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the Contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- N. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

1.5 QUALITY ASSURANCE

- A. Mechanical, electrical and associated systems shall be safe, reliable, efficient, durable, easily and safely operable and maintainable, easily and safely accessible, and in compliance with applicable codes as specified. The systems shall be comprised of high quality institutional-class and industrial-class products of manufacturers that are experienced specialists in the required product lines. All construction firms and personnel shall be experienced and qualified specialists in industrial and institutional HVAC.
- B. Flow Rate Tolerance for HVAC Equipment: Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
- C. Equipment Vibration Tolerance:
1. Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT. Equipment shall be factory-balanced to this tolerance and re-balanced on site, as necessary.
 2. After HVAC air balance work is completed and permanent drive sheaves are in place, perform field mechanical balancing and adjustments required to meet the specified vibration tolerance.
- D. Products Criteria:
1. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years (or longer as specified elsewhere). The design, model and size of each item shall have been in satisfactory and efficient operation on at least three installations for approximately three years. However, digital electronics devices, software and systems such as controls, instruments, computer work station, shall be the current generation of technology and basic design that has a proven satisfactory service record of at least three years. See other specification sections for any exceptions and/or additional requirements.
 2. Refer to all other sections for quality assurance requirements for systems and equipment specified therein.
 3. All items furnished shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components and overall assembly.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

4. The products and execution of work specified in Division 33 shall conform to the referenced codes and standards as required by the specifications. Local codes and amendments shall be enforced, along with requirements of local utility companies. The most stringent requirements of these specifications, local codes, or utility company requirements shall always apply. Any conflicts shall be brought to the attention of the COR.
 5. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be of the same manufacturer and model number, or if different models are required they shall be of the same manufacturer and identical to the greatest extent possible (i.e., same model series).
 6. Assembled Units: Performance and warranty of all components that make up an assembled unit shall be the responsibility of the manufacturer of the completed assembly.
 7. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped or otherwise permanently marked on each item of equipment.
 8. Use of asbestos products or equipment or materials containing asbestos is prohibited.
- E. HVAC Equipment Service Providers: Service providers shall be authorized and trained by the manufacturers of the equipment supplied. These providers shall be capable of responding onsite and provide acceptable service to restore equipment operations within 4 hours of receipt of notification by phone, e-mail or fax in event of an emergency, such as the shutdown of equipment; or within 24 hours in a non-emergency. Submit names, mail and e-mail addresses and phone numbers of service personnel and companies providing service under these conditions for (as applicable to the project): fans, air handling units, control systems, pumps, critical instrumentation, programming.
- F. Manufacturer's Recommendations: Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the COR with submittals.

Installation of the item will not be allowed to proceed until the
Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material and removal by the Contractor and no additional cost or time to the Government.

G. Execution (Installation, Construction) Quality:

1. Apply and install all items in accordance with manufacturer's written instructions. Refer conflicts between the manufacturer's instructions and the contract documents to the COR for resolution. Provide written hard copies and computer files on CD or DVD of manufacturer's installation instructions to the COR with submittals prior to commencing installation of any item. Installation of the item will not be allowed to proceed until the recommendations are received and approved by the VA. Failure to furnish these recommendations is a cause for rejection of the material.
2. All items that require access, such as for operating, cleaning, servicing, maintenance, and calibration, shall be easily and safely accessible by persons standing at floor level, or standing on permanent platforms, without the use of portable ladders. Examples of these items include, but are not limited to, all types of valves, filters and strainers, transmitters, control devices. Prior to commencing installation work, refer conflicts between this requirement and contract documents to the COR for resolution. Failure of the Contractor to resolve, or point out any issues will result in the Contractor correcting at no additional cost or time to the Government.
3. Complete coordination/shop drawings shall be required in accordance with Article, SUBMITTALS. Construction work shall not start on any system until the coordination/shop drawings have been approved by VA.
4. Workmanship/craftsmanship will be of the highest quality and standards. The VA reserves the right to reject any work based on poor quality of workmanship this work shall be removed and done again at no additional cost or time to the Government.

H. Upon request by Government, provide lists of previous installations for selected items of equipment. Include contact persons who will serve as references, with current telephone numbers and e-mail addresses.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

I. Guaranty: Warranty of Construction, FAR Clause 52.246-21.

1.6 DELIVERY, STORAGE AND HANDLING

A. Protection of Equipment:

1. Equipment and material placed on the job site shall remain in the custody of the Contractor until phased acceptance, whether or not the Government has reimbursed the Contractor for the equipment and material. The Contractor is solely responsible for the protection of such equipment and material against any damage or theft.
2. Repair damaged equipment in first class, new operating condition and appearance; or, replace same as determined and directed by the COR. Such repair or replacement shall be at no additional cost or time to the Government.
3. Protect interiors of new equipment and piping systems against entry of foreign matter. Clean both inside and outside before painting or placing equipment in operation.
4. Existing equipment and piping being worked on by the Contractor shall be under the custody and responsibility of the Contractor and shall be protected as required for new work.

B. Cleanliness of Piping and Equipment Systems:

1. Exercise care in storage and handling of equipment and piping material to be incorporated in the work. Remove debris arising from cutting, threading and welding of piping.
2. Piping systems shall be flushed, blown or pigged as necessary to deliver clean systems.
3. Contractor shall be fully responsible for all costs, damage, and delay arising from failure to provide clean systems.

1.7 AS-BUILT DOCUMENTATION

- A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- B. Submit operation and maintenance data updated to include submittal review comments, VA approved substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three-ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

- C. The installing Contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing Contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement. Provide record drawings as follows:

1. As-built drawings are to be provided, with a copy of them on AutoCAD version AutoCad 14 provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.

- D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.

- E. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics_), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

1.8 JOB CONDITIONS - WORK IN EXISTING BUILDING

- A. Building Operation: Government employees will be continuously operating and managing all facilities, including temporary facilities that serve the VAMC.
- B. Maintenance of Service: Schedule all work to permit continuous service as required by the VAMC.
- C. Steam and Condensate Service Interruptions: Limited steam and condensate service interruptions, as required for interconnections of new and existing systems, will be permitted by the COR during periods when the demands are not critical to the operation of the VAMC. These non-critical periods are limited to between 8 pm and 5 am in the appropriate off-season (if applicable). Provide at least 10 working days advance notice to the COR. The request shall include a detailed plan on the proposed shutdown and the intended work to be done along with manpower levels. All equipment and materials must be onsite and verified with plan 5 days prior to the shutdown or it will need to be rescheduled.
- D. Phasing of Work: Comply with all requirements shown on contract documents. Contractor shall submit a complete detailed phasing plan/schedule with manpower levels prior to commencing work. The phasing plan shall be detailed enough to provide milestones in the process that can be verified.
- E. Building Working Environment: Maintain the architectural and structural integrity of the building and the working environment at all times. Maintain the interior of building at 18 degrees C (65 degrees F) minimum. Limit the opening of doors, windows or other access openings to brief periods as necessary for rigging purposes. Storm water or ground water leakage is prohibited. Provide daily clean-up of construction and demolition debris on all floor surfaces and on all equipment being operated by VA. Maintain all egress routes and safety systems/devices.
- F. Acceptance of Work for Government Operation: As new equipment, systems and facilities are made available for operation and these items are deemed of beneficial use to the Government, inspections will be made and tests will be performed. Based on the inspections, a list of contract deficiencies will be issued to the Contractor. After

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

correction of deficiencies as necessary for beneficial use, the Contracting Officer will process necessary acceptance and the equipment will then be under the control and operation of Government personnel.

PART 2 - PRODUCTS

2.1 FACTORY-ASSEMBLED PRODUCTS

- A. Provide maximum standardization of components to reduce spare part requirements.
- B. Performance and warranty of all components that make up an assembled unit shall be the responsibility of the manufacturer of the completed assembly.
 - 1. All components of an assembled unit need not be products of same manufacturer.
 - 2. Constituent parts that are alike shall be products of a single manufacturer.
 - 3. Components shall be compatible with each other and with the total assembly for intended service.
 - 4. Contractor shall guarantee performance of assemblies of components, and shall repair or replace elements of the assemblies as required to deliver specified performance of the complete assembly.
- C. Equipment and components of equipment shall bear manufacturer's name and trademark, model number, serial number and performance data on a nameplate securely affixed in a conspicuous place, or cast integral with, stamped or otherwise permanently marked upon the components of the equipment.
- D. Major items of equipment, which serve the same function, must be the same make and model. Exceptions must be approved by the VA, but may be permitted if performance requirements cannot be met.

2.2 COMPATIBILITY OF RELATED EQUIPMENT

- A. Equipment and materials installed shall be compatible in all respects with other items being furnished and with existing items so that the result will be a complete and fully operational plant that conforms to contract requirements.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

02-01-20

2.3 V-BELT DRIVES (NOT USED)

2.4 SYNCHRONOUS BELT DRIVES (NOT USED)

2.5 DRIVE GUARDS (NOT USED)

2.6 LIFTING ATTACHMENTS

- A. Provide equipment with suitable lifting attachments to enable equipment to be lifted in its normal position. Lifting attachments shall withstand any handling conditions that might be encountered, without bending or distortion of shape, such as rapid lowering and braking of load.

2.7 ELECTRIC MOTORS

- A. All material and equipment furnished and installation methods shall conform to the requirements of Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT; Section 26 29 11, MOTOR CONTROLLERS; and, Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES. Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems. Provide special energy efficient premium efficiency type motors as scheduled.

2.8 VARIABLE SPEED MOTOR CONTROLLERS

- A. Refer to Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS and Section 26 29 11, MOTOR CONTROLLERS for specifications.
- B. Coordinate variable speed motor controller communication protocol with Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- C. Motors shall be premium efficiency type and be approved by the motor controller manufacturer. The controller-motor combination shall be guaranteed to provide full motor nameplate horsepower in variable frequency operation. Both driving and driven motor/fan sheaves shall be fixed pitch.
- D. Controller shall not add any current or voltage transients to the input ac power distribution system, DDC controls, sensitive medical equipment, etc., nor shall be affected from other devices on the ac power system.

2.9 EQUIPMENT AND MATERIALS IDENTIFICATION

- A. Use symbols, nomenclature and equipment numbers specified, shown on the contract documents and shown in the maintenance manuals. Identification for piping is specified in Section 09 91 00, PAINTING.

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

- B. Interior (Indoor) Equipment: Engraved nameplates, with letters not less than 5 mm (3/16 inch) high of brass with black-filled letters, or rigid black plastic with white letters specified in Section 09 91 00, PAINTING permanently fastened to the equipment. Identify CRAC units split system DX fan coils and VRF units etc.
- C. Exterior (Outdoor) Equipment: Brass nameplates, with engraved black filled letters, not less than 5 mm (3/16 inch) high riveted or bolted to the equipment.
- D. Control Items: Label all instrumentation, temperature and humidity sensors, controllers and control dampers. Identify and label each item as they appear on the control diagrams.
- E. Valve Tags and Lists:
 - 1. Valve tags: Engraved black filled numbers and letters not less than 15 mm (1/2 inch) high for number designation, and not less than 6 mm (1/4 inch) for service designation on 19-gauge 40 mm (1-1/2 inches) round brass disc, attached with brass "S" hook or brass chain.

2.10 FIRESTOPPING

- A. Section 07 84 00, FIRESTOPPING specifies an effective barrier against the spread of fire, smoke and gases where penetrations occur for piping and ductwork. Refer to Section 23 07 11, HVAC AND BOILER PLANT INSULATION, for firestop pipe and duct insulation.

2.11 GALVANIZED REPAIR COMPOUND

- A. Mil-P-21035B, paint form.

2.12 HVAC PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS

- A. Vibration Isolators: Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- B. Supports for Roof Mounted Items:
 - 1. Equipment: Equipment rails shall be galvanized steel, minimum 1.3 mm (18 gauge), with integral baseplate, continuous welded corner seams, factory installed 50 by 100 mm (2 by 4 inches) treated wood nailer, 1.3 mm (18 gauge) galvanized steel counter flashing cap with screws, built-in cant strip, (except for gypsum or tectum deck), minimum height 275 mm (11 inches). For surface insulated roof deck, provide raised cant strip to start at the upper surface of the insulation.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

2. Pipe/duct pedestals: Provide a galvanized Unistrut channel welded to U-shaped mounting brackets which are secured to side of rail with galvanized lag bolts.
- C. Pipe Supports: Comply with MSS SP-58. Type Numbers specified refer to this standard. For selection and application comply with MSS SP-58. Refer to Section 05 50 00, METAL FABRICATIONS, for miscellaneous metal support materials and prime coat painting requirements.
- D. Attachment to Concrete Building Construction:
 1. Concrete insert: MSS SP-58, Type 18.
 2. Self-drilling expansion shields and machine bolt expansion anchors: Permitted in concrete not less than 100 mm (4 inches) thick when approved by the COR for each job condition.
 3. Power-driven fasteners: Permitted in existing concrete or masonry not less than 100 mm (4 inches) thick when approved by the COR for each job condition.
- E. Attachment to Steel Building Construction:
 1. Welded attachment: MSS SP-58, Type 22.
 2. Beam clamps: MSS SP-58, Types 20, 21, 28 or 29. Type 23 C-clamp may be used for individual copper tubing up to 23 mm (7/8 inch) outside diameter.
- F. Attachment to existing structure: Support from existing floor/roof frame.
- G. Hanger Rods: Hot-rolled steel, ASTM A36/A36M or ASTM A575 for allowable load listed in MSS SP-58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turn-buckles shall provide 40 mm (1-1/2 inches) minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.
- H. Hangers Supporting Multiple Pipes (Trapeze Hangers): Galvanized, cold formed, lipped steel channel horizontal member, not less than 41 mm by 41 mm (1-5/8 inches by 1-5/8 inches), 2.7 mm (12 gauge), designed to accept special spring held, hardened steel nuts. Trapeze hangers are prohibited for use for steam supply and condensate piping.
 1. Allowable hanger load: Manufacturers rating less 91 kg (200 pounds).
 2. Guide individual pipes on the horizontal member of every other trapeze hanger with 6 mm (1/4 inch) U-bolt fabricated from steel

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

rod. Provide Type 40 insulation shield, secured by two 15 mm (1/2 inch) galvanized steel bands, or preinsulated calcium silicate shield for insulated piping at each hanger.

I. Supports for Piping Systems:

1. Select hangers sized to encircle insulation on insulated piping. Refer to Section 23 07 11, HVAC AND BOILER PLANT INSULATION for insulation thickness. To protect insulation, provide Type 39 saddles for roller type supports or preinsulated calcium silicate shields. Provide Type 40 insulation shield or preinsulated calcium silicate shield at all other types of supports and hangers including those for preinsulated piping.
2. Piping Systems except High and Medium Pressure Steam (MSS SP-58):
 - a. Standard clevis hanger: Type 1; provide locknut.
 - b. Riser clamps: Type 8.
 - c. Wall brackets: Types 31, 32 or 33.
 - d. Roller supports: Type 41, 43, 44 and 46.
 - e. Saddle support: Type 36, 37 or 38.
 - f. Turnbuckle: Types 13 or 15. Preinsulate.
 - g. U-bolt clamp: Type 24.
 - h. Copper Tube:
 - 1) Hangers, clamps and other support material in contact with tubing shall be painted with copper colored epoxy paint, plastic coated or taped with non-adhesive isolation tape to prevent electrolysis.
 - 2) For vertical runs use epoxy painted or plastic-coated riser clamps.
 - 3) For supporting tube to strut: Provide epoxy painted pipe straps for copper tube or plastic inserted vibration isolation clamps.
 - 4) Insulated Lines: Provide pre-insulated calcium silicate shields sized for copper tube.

2.13 PIPE PENETRATIONS

A. Install sleeves during construction for other than blocked out floor openings for risers in mechanical bays.

B. To prevent accidental liquid spills from passing to a lower level, provide the following:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

1. For sleeves: Extend sleeve 25 mm (1 inch) above finished floor and provide sealant for watertight joint.
 2. For blocked out floor openings: Provide 40 mm (1-1/2 inch) angle set in silicone adhesive around opening.
 3. For drilled penetrations: Provide 40 mm (1-1/2 inch) angle ring or square set in silicone adhesive around penetration.
- C. Penetrations through beams or ribs are prohibited, but may be installed in concrete beam flanges. Any deviation from these requirements must receive prior approval of COR.
- D. Sheet Metal, Plastic, or Moisture-resistant Fiber Sleeves: Provide for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.
- E. Cast Iron or Zinc Coated Pipe Sleeves: Provide for pipe passing through exterior walls below grade. Make space between sleeve and pipe watertight with a modular or link rubber seal. Seal shall be applied at both ends of sleeve.
- F. Galvanized Steel or an alternate Black Iron Pipe with asphalt coating Sleeves: Provide for pipe passing through concrete beam flanges, except where brass pipe sleeves are called for. Provide sleeve for pipe passing through floor of mechanical rooms, laundry work rooms, and animal rooms above basement. Except in mechanical rooms, connect sleeve with floor plate.
- G. Brass Pipe Sleeves: Provide for pipe passing through quarry tile, terrazzo or ceramic tile floors. Connect sleeve with floor plate.
- H. Sleeves are not required for wall hydrants for fire department connections or in drywall construction.
- I. Sleeve Clearance: Sleeve through floors, walls, partitions, and beam flanges shall be one inch greater in diameter than external diameter of pipe. Sleeve for pipe with insulation shall be large enough to accommodate the insulation. Interior openings shall be caulked tight with fire stopping material and sealant to prevent the spread of fire, smoke, and gases.
- J. Sealant and Adhesives: Shall be as specified in Section 07 92 00, JOINT SEALANTS.

2.14 DUCT PENETRATIONS

- A. Provide curbs for roof mounted piping, ductwork and equipment. Curbs shall be 450 mm (18 inches) high with continuously welded seams, built-in cant strip, interior baffle with acoustic insulation, curb bottom, hinged curb adapter.
- B. Provide firestopping for openings through fire and smoke barriers, maintaining minimum required rating of floor, ceiling or wall assembly. See section 07 84 00, FIRESTOPPING.

2.15 SPECIAL TOOLS AND LUBRICANTS

- A. Furnish, and turn over to the COR, tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.
- B. Grease Guns with Attachments for Applicable Fittings: One for each type of grease required for each motor or other equipment.
- C. Refrigerant Tools: Provide system charging/Evacuation equipment, gauges, fittings, and tools required for maintenance of furnished equipment.
- D. Tool Containers: Hardwood or metal, permanently identified for intended service and mounted, or located, where directed by the COR.
- E. Lubricants: A minimum of 0.95 L (1 quart) of oil, and 0.45 kg (1 pound) of grease, of equipment manufacturer's recommended grade and type, in unopened containers and properly identified as to use for each different application.

2.16 WALL, FLOOR AND CEILING PLATES (NOT USED)

2.17 ASBESTOS

- A. Materials containing asbestos are prohibited.

PART 3 - EXECUTION

3.1 GENERAL

- A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

3.2 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING

- A. Location of piping, sleeves, inserts, hangers, and equipment, access provisions shall be coordinated with the work of all trades. The coordination/shop drawings shall be submitted for review. Locate piping, sleeves, inserts, hangers, ductwork and equipment clear of

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

windows, doors, openings, light outlets, and other services and utilities. Equipment coordination/shop drawings shall be prepared to coordinate proper location and personnel access of all facilities. The drawings shall be submitted for review. Follow manufacturer's published recommendations for installation methods not otherwise specified.

- B. Operating Personnel Access and Observation Provisions: Select and arrange all equipment and systems to provide clear view and easy access, without use of portable ladders, for maintenance and operation of all devices including, but not limited to: all equipment items, valves, filters, strainers, transmitters, sensors, control devices. All gauges and indicators shall be clearly visible by personnel standing on the floor or on permanent platforms. Do not reduce or change maintenance and operating space and access provisions that are shown on the contract documents.
- C. Equipment and Piping Support: Coordinate structural systems necessary for pipe and equipment support with pipe and equipment locations to permit proper installation.
- D. Location of pipe sleeves, trenches and chases shall be accurately coordinated with equipment and piping locations.
- E. Cutting Holes:

1. Cut holes through concrete and masonry by rotary core drill. Pneumatic hammer, impact electric, and hand or manual hammer type drill is prohibited, except as permitted by COR where working area space is limited.
2. Locate holes to avoid interference with structural members such as slabs, columns, ribs, beams or reinforcing. Holes shall be laid out in advance and drilling done only after approval by COR. If the Contractor considers it necessary to drill through structural members, this matter shall be referred to COR for approval.
3. Do not penetrate membrane waterproofing.

- F. Minor Piping: Generally, small diameter pipe runs from drips and drains, water cooling, and other service are not shown but must be provided.

- G. Electrical Interconnection of Instrumentation or Controls: This generally not shown but must be provided. This includes

interconnections of sensors, transmitters, transducers, control

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

devices, control and instrumentation panels, instruments and computer workstations. Devices shall be located so they are easily accessible for testing, maintenance, calibration, etc. The COR has the final determination on what is accessible and what is not. Comply with NFPA 70.

H. Protection and Cleaning:

1. Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations and as approved by the COR. Damaged or defective items in the opinion of the COR, shall be replaced.
2. Protect all finished parts of equipment, such as shafts and bearings where accessible, from rust prior to operation by means of protective grease coating and wrapping. Close pipe openings with caps or plugs during installation. Tightly cover and protect fixtures and equipment against dirt, water chemical, or mechanical injury. At completion of all work thoroughly clean fixtures, exposed materials and equipment.

I. Concrete and Grout: Use concrete and non-shrink grout 20 MPa (3000 psig) minimum, specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

J. Install gauges, thermometers, valves and other devices with due regard for ease in reading or operating and maintaining said devices. Locate and position thermometers and gauges to be easily read by operator or staff standing on floor or walkway provided. Servicing shall not require dismantling adjacent equipment or pipe work.

K. Install steam piping expansion joints as per manufacturer's recommendations.

L. Work in Existing Building:

1. Perform as specified in Article, OPERATIONS AND STORAGE AREAS, Article, ALTERATIONS, and Article, RESTORATION of the Section 01 00 00, GENERAL REQUIREMENTS for relocation of existing equipment, alterations and restoration of existing building(s).
2. As specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, OPERATIONS AND STORAGE AREAS, make alterations to existing service piping at times that will least interfere with normal operation of the facility.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

- M. Work in Animal Research Areas: Seal all pipe and duct penetrations with silicone sealant to prevent entrance of insects.
- N. Switchgear/Electrical Equipment Drip Protection: Every effort shall be made to eliminate the installation of pipe above electrical and data/telephone switchgear. If this is not possible, encase pipe in a second pipe with a minimum of joints. Installation of piping, ductwork, leak protection apparatus or other installations foreign to the electrical installation shall not be located in the space equal to the width and depth of the equipment and extending from to a height of 1.8 m (6 feet) above the equipment or to ceiling structure, whichever is lower (NFPA 70).
- O. Inaccessible Equipment:
1. Where the Government determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance or inspections, equipment shall be removed and reinstalled or remedial action performed as directed at no additional cost or time to the Government.
 2. The term "conveniently accessible" is defined as capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as, but not limited to motors, fans, pumps, belt guards, transformers, high voltage lines, conduit and raceways, piping, hot surfaces, and ductwork. The COR has final determination on whether an installation meets this requirement or not.

3.3 TEMPORARY PIPING AND EQUIPMENT

- A. Continuity of operation of existing facilities will generally require temporary installation or relocation of equipment and piping.
- B. The Contractor shall provide all required facilities in accordance with the requirements of phased construction and maintenance of service. All piping and equipment shall be properly supported, sloped to drain, operate without excessive stress, and shall be insulated where injury can occur to personnel by contact with operating facilities. The requirements of Article, ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING apply.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

- C. Temporary facilities and piping shall be completely removed and any openings in structures sealed. Provide necessary blind flanges and caps to seal open piping remaining in service.

3.4 RIGGING

- A. Design is based on application of available equipment. Openings in building structures are planned to accommodate design scheme.
- B. Alternative methods of equipment delivery may be offered by Contractor and will be considered by Government under specified restrictions of phasing and maintenance of service requirements as well as structural integrity of the building.
- C. Close all openings in the building when not required for rigging operations to maintain proper environment in the facility for Government operation and maintenance of service.
- D. Contractor shall provide all facilities required to deliver specified equipment and place on foundations. Attachments to structures for rigging purposes and support of equipment on structures shall be Contractor's full responsibility. Upon request, the Government will check structure adequacy and advise Contractor of recommended restrictions.
- E. Contractor shall check all clearances, weight limitations and shall offer a rigging plan designed by a Registered Professional Engineer. All modifications to structures, including reinforcement thereof, shall be at Contractor's cost, time and responsibility.
- F. Follow approved rigging plan.
- G. Restore building to original condition upon completion of rigging work.

3.5 PIPE AND EQUIPMENT SUPPORTS

- A. Where hanger spacing does not correspond with joist or rib spacing, use structural steel channels designed by a structural engineer, secured directly to joist and rib structure that will correspond to the required hanger spacing, and then suspend the equipment and piping from the channels. Drill or burn holes in structural steel only with the prior approval of the COR.
- B. Use of chain pipe supports; wire or strap hangers; wood for blocking, stays and bracing; or, hangers suspended from piping above are prohibited. Replace or thoroughly clean rusty products and paint with zinc primer.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

- C. Hanger rods shall be used that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. Provide a minimum of 15 mm (1/2 inch) clearance between pipe or piping covering and adjacent work.
- D. HVAC Horizontal Pipe Support Spacing: Refer to MSS SP-58. Provide additional supports at valves, strainers, in-line pumps and other heavy components. Provide a support within one foot of each elbow.
- E. HVAC Vertical Pipe Supports:
1. Up to 150 mm (6-inch pipe), 9 m (30 feet) long, bolt riser clamps to the pipe below couplings, or welded to the pipe and rests supports securely on the building structure.
 2. Vertical pipe larger than the foregoing, support on base elbows or tees, or substantial pipe legs extending to the building structure.
- F. Overhead Supports:
1. /The basic structural system of the building is designed to sustain the loads imposed by equipment and piping to be supported overhead.
 2. Provide steel structural members, in addition to those shown, of adequate capability to support the imposed loads, located in accordance with the final approved layout of equipment and piping.
 3. Tubing and capillary systems shall be supported in channel troughs.
 4. All equipment shall be shimmed, leveled, firmly anchored, and grouted with epoxy grout. Anchor bolts shall be placed in sleeves, anchored to the bases. Fill the annular space between sleeves and bolts with a granular material to permit alignment and realignment.

3.6 MECHANICAL DEMOLITION

- A. Unless specified otherwise, all piping, wiring, conduit, and other devices associated with the equipment not re-used in the new work shall be completely removed from Government property per Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT. This includes all concrete pads, pipe, valves, fittings, insulation, and all hangers including the top connection and any fastenings to building structural systems. All openings shall be sealed after removal of equipment, pipes, ducts, and

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

other penetrations in roof, walls, floors, in an approved manner and in accordance with contract documents where specifically covered.

Structural integrity of the building system shall be maintained.

Reference shall also be made to the contract documents of the other disciplines in the project for additional facilities to be demolished or handled.

- B. All indicated valves including gate, globe, ball, butterfly and check, all pressure gauges and thermometers with wells shall remain Government property and shall be removed and delivered to COR and stored as directed. The Contractor shall remove all other material and equipment, devices and demolition debris under these contract documents. Such material shall be removed from Government property expeditiously and shall not be allowed to accumulate.

3.7 CLEANING AND PAINTING

- A. Prior to final inspection and acceptance of the plant and facilities for beneficial use by the Government, the plant facilities, equipment and systems shall be thoroughly cleaned and painted. Refer to Section 09 91 00, PAINTING.

- B. In addition, the following special conditions apply:

1. Cleaning shall be thorough. Solvents, cleaning materials and methods recommended by the manufacturers shall be used for the specific tasks. All rust shall be removed prior to painting and from surfaces to remain unpainted. Repair scratches, scuffs, and abrasions prior to applying prime and finish coats.
2. The following material and equipment shall not be painted:
 - a. Motors, controllers, control switches, and safety switches.
 - b. Control and interlock devices.
 - c. Control valves and thermostatic elements.
 - d. Lubrication devices and grease fittings.
 - e. Copper, brass, aluminum, stainless steel and bronze surfaces.
 - f. Valve stems and rotating shafts.
 - g. Pressure gauges and thermometers.
 - h. Glass.
 - i. Nameplates.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

3. Control and instrument panels shall be cleaned, damaged surfaces repaired, and shall be touched-up with matching paint obtained from panel manufacturer.

3.8 IDENTIFICATION SIGNS

- A. Provide laminated plastic signs, with engraved lettering not less than 5 mm (3/16 inch) high, designating functions, for all equipment, switches, motor controllers, relays, meters, control devices, including automatic control valves. Nomenclature and identification symbols shall correspond to that used in maintenance manual, and in diagrams specified elsewhere. Attach by chain, adhesive, or screws.
- B. Factory Built Equipment: Metal plate, securely attached, with name and address of manufacturer, serial number, model number, size, performance.
- C. Pipe Identification: Refer to Section 09 91 00, PAINTING.
- D. Attach ceiling grid label on ceiling grid location directly underneath above-ceiling air terminal, control system component, valve, filter unit, fan etc.

3.9 MOTOR AND DRIVES (NOT USED)

3.10 LUBRICATION

- A. All equipment and devices requiring lubrication shall be lubricated prior to initial operation. Field-check all devices for proper lubrication.
- B. All lubrication points shall be accessible without disassembling equipment, except to remove access plates.
- C. All lubrication points shall be extended to one side of the equipment.

3.11 STARTUP, TEMPORARY OPERATION AND TESTING

- A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.
- B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.
- C. The Commissioning Agent will observe startup and Contractor testing of selected equipment. Coordinate the startup and Contractor testing

schedules with COR and Commissioning Agent. Provide a minimum notice of
Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

10 working days prior to startup and testing. Startup of equipment shall be performed as described in equipment specifications. Vibration within specified tolerance shall be verified prior to extended operation. Temporary use of equipment is specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TEMPORARY USE OF MECHANICAL AND ELECTRICAL EQUIPMENT.

3.12 OPERATING AND PERFORMANCE TESTS

- A. Prior to the final inspection, perform required tests as specified in Section 01 00 00, GENERAL REQUIREMENTS Article, TESTS, and in individual Division 23 specification sections and submit the test reports and records to the COR.
- B. Should evidence of malfunction in any tested system, or piece of equipment or component part thereof, occur during or as a result of tests, make proper corrections, repairs or replacements, and repeat tests at no additional cost or time to the Government.
- C. When completion of certain work or system occurs at a time when final control settings and adjustments cannot be properly made to make performance tests, then conduct such performance tests and finalize control settings for heating systems and for cooling systems respectively during first actual seasonal use of respective systems following completion of work. Rescheduling of these tests shall be requested in writing to COR for approval.
- D. No adjustments may be made during the acceptance inspection. All adjustments shall have been made by this point.
- E. Perform tests as required for commissioning provisions in accordance with Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

3.13 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- B. Components provided under this section of the specification will be tested as part of a larger system.

3.14 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

B. Submit training plans and instructor qualifications in accordance with
the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

23 05 11 - 31
Common Work Results for HVAC

SECTION 23 05 12
GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation and connection of motors for HVAC and steam generation equipment.
- B. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.
- D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
- E. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- F. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- G. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- H. Section 26 29 11, MOTOR CONTROLLERS.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.
- B. American Bearing Manufacturers Association (ABMA):
 - 9-2015.....Load Ratings and Fatigue Life for Ball Bearings
 - 11-2014.....Load Ratings and Fatigue Life for Roller Bearings
- C. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
 - 90.1-2013.....Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings
- D. Institute of Electrical and Electronics Engineers (IEEE):
 - 112-2017.....Standard Test Procedure for Polyphase Induction Motors and Generators
 - 841-2009.....IEEE Standard for Petroleum and Chemical Industry-Premium-Efficiency, Severe-Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades- Tier 2
Bancroft Architects + Engineers

02-01-20

Cage Induction Motors--Up to and Including 370
kW (500 hp)

E. National Electrical Manufacturers Association (NEMA):

MG 1-2019.....Motors and Generators

MG 2-2014.....Safety Standard for Construction and Guide for
Selection, Installation and Use of Electric
Motors and Generators

250-2014.....Enclosures for Electrical Equipment (1000 Volts
Maximum)

F. National Fire Protection Association (NFPA):

70-2014.....National Electrical Code (NEC)

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in
accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND
SAMPLES.

B. Information and material submitted under this section shall be marked
"SUBMITTED UNDER SECTION 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC
AND STEAM GENERATION EQUIPMENT", with applicable paragraph
identification.

C. Submit motor submittals with driven equipment.

D. Shop Drawings:

1. Provide documentation to demonstrate compliance with contract
documents.

2. Motor nameplate information shall be submitted including electrical
ratings, efficiency, bearing data, power factor, frame size,
dimensions, mounting details, materials, horsepower, voltage, phase,
speed (RPM), enclosure, starting characteristics, torque
characteristics, code letter, full load and locked rotor current,
service factor, and lubrication method.

E. Manufacturer's Literature and Data including: Full item description and
optional features and accessories. Include dimensions, weights,
materials, applications, standard compliance, model numbers, size, and
capacity.

F. Complete operating and maintenance manuals including wiring diagrams,
technical data sheets, information for ordering replacement parts, and
troubleshooting guide:

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

23 05 12 - 2

General Motor Requirements for HVAC Equipment

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades- Tier 2
Bancroft Architects + Engineers

02-01-20

1. Include complete list indicating all components of the systems.
 2. Include complete diagrams of the internal wiring for each item of equipment.
 3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.
- G. Certification: Two weeks prior to final inspection, unless otherwise noted, certification shall be submitted to the COR stating that the motors have been properly applied, installed, adjusted, lubricated, and tested.
- H. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- I. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 AS-BUILT DOCUMENTATION

- A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- B. Submit operation and maintenance data updated to include submittal review comments, VA approved substitutions and construction revisions shall be in electronic version on CD or DVD and 3 copies inserted into a three-ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.
- C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the

installing contractor engage the testing company to provide as-built or
Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades- Tier 2
Bancroft Architects + Engineers

02-01-20

any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement. Provide record drawings as follows:

1. As-built drawings are to be provided, with a copy of them on AutoCAD version 2014 or newer provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.
- D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.
- E. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

PART 2 - PRODUCTS

2.1 MOTORS

- A. For alternating current, fractional and integral horsepower motors, NEMA MG 1 and NEMA MG 2 shall apply.
- B. For severe duty TEFC motors, IEEE 841 shall apply.
- C. All material and equipment furnished and installation methods shall conform to the requirements of Section 26 29 11, MOTOR CONTROLLERS; and Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES. Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems. Provide premium efficiency type motors. Unless otherwise specified for a

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades- Tier 2
Bancroft Architects + Engineers

02-01-20

particular application, use electric motors with the following requirements.

- D. Single-phase Motors: Motors for centrifugal fans and pumps may be split phase or permanent split capacitor (PSC) type. Provide capacitor-start type for hard starting applications.
- E. Poly-phase Motors: NEMA Design B, Squirrel cage, induction type.
 - 1. Two Speed Motors: Each two-speed motor shall have two separate windings. Provide a time- delay (20 seconds minimum) relay for switching from high to low speed.
- F. Voltage ratings shall be as follows:
 - 1. Single phase:
 - a. Motors connected to 120-volt systems: 115 volts.
 - b. Motors connected to 208-volt systems: 200 volts.
 - c. Motors connected to 240-volt or 480-volt systems: 230/460 volts, dual connection.
 - 2. Three phase:
 - a. Motors connected to 208-volt systems: 200 volts.
 - b. Motors, less than 74.6 kW (100 hp), connected to 240-volt or 480-volt systems: 208-230/460 volts, dual connection.
- G. Number of phases shall be as follows:
 - 1. Motors, less than 373 W (1/2 hp): Single phase.
 - 2. Motors, 373 W (1/2 hp) and larger: 3 phase.
 - 3. Exceptions:
 - a. Hermetically sealed motors.
 - b. Motors for equipment assemblies, less than 746 W (1 hp), may be single phase provided the manufacturer of the proposed assemblies cannot supply the assemblies with three phase motors.
- H. Horsepower ratings shall be adequate for operating the connected loads continuously in the prevailing ambient temperatures in areas where the motors are installed, without exceeding the NEMA standard temperature rises for the motor insulation. Motor designs, as indicated by the NEMA code letters, shall be coordinated with the connected loads to assure adequate starting, acceleration, and running torque without exceeding nameplate ratings or considering service factor.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades- Tier 2
Bancroft Architects + Engineers

02-01-20

I. Motor Enclosures:

1. Shall be the NEMA types as specified and/or shown in the Contract Documents.
2. Where the types of motor enclosures are not shown on the drawings, they shall be the NEMA types per NEMA 250, which are most suitable for the environmental conditions where the motors are being installed. Enclosure requirements for certain conditions are as follows:
 - a. Motors located outdoors, indoors in wet or high humidity locations, or in unfiltered airstreams shall be totally enclosed type.
 - b. Where motors are located in an NEC 511 classified area, provide TEFC explosion proof motor enclosures.
 - c. Where motors are located in a corrosive environment, provide TEFC enclosures with corrosion resistant finish.
3. Enclosures shall be primed and finish coated at the factory with manufacturer's prime coat and standard finish.

J. Electrical Design Requirements:

1. Motors shall be continuous duty.
2. The insulation system shall be rated minimum of Class B, 130 degrees C (266 degrees F).
3. The maximum temperature rise by resistance at rated power shall not exceed Class B limits, 80 degrees C (176 degrees F).
4. The speed/torque and speed/current characteristics shall comply with NEMA Design A or B, as specified.
5. Motors shall be suitable for full voltage starting, unless otherwise noted. Coordinate motor features with applicable motor controllers.
6. Motors for variable frequency drive applications shall adhere to NEMA MG 1, Part 30, Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General-Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both, or NEMA MG 1, Part 31, Definite-Purpose Inverter-Fed Polyphase Motors.

K. Mechanical Design Requirements:

1. Bearings shall be rated in accordance with ABMA 9 or ABMA 11 for a minimum fatigue life of 26,280 hours for belt-driven loads and

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades- Tier 2
Bancroft Architects + Engineers

02-01-20

100,000 hours for direct-drive loads based on L10 (Basic Rating Life) at full load direct coupled, except vertical high thrust motors which require a 40,000 hours rating. A minimum fatigue life of 40,000 hours is required for VFD drives.

2. Vertical motors shall be capable of withstanding a momentary up thrust of at least 30 percent of normal down thrust.
3. Vibration shall not exceed 3.8 mm (0.15 inch) per second, unfiltered peak.
4. Noise level shall meet the requirements of the application.
5. All external fasteners shall be corrosion resistant.
6. Winding thermostats, when specified shall be normally closed, connected in series.
7. Grounding provisions shall be in the main terminal box.

L. Special Requirements:

1. Where motor power requirements of equipment furnished deviate from power shown on plans, provide electrical service designed under the requirements of NFPA 70 without additional cost or time to the Government.
2. Assemblies of motors, starters, controls and interlocks on factory assembled and wired devices shall be in accordance with the requirements of this specification.
3. Wire and cable materials specified in the electrical division of the specifications shall be modified as follows:
 - a. Wiring material located where temperatures can exceed 71 degrees C (160 degrees F) shall be stranded copper with Teflon FEP insulation with jacket. This includes wiring on the boilers.
 - b. Other wiring at boilers and to control panels shall be NFPA 70 designation THWN.
 - c. Provide shielded conductors or wiring in separate conduits for all instrumentation and control systems where recommended by manufacturer of equipment.
4. Select motor sizes so that the motors do not operate into the service factor at maximum required loads on the driven equipment. Motors on pumps shall be sized for non-overloading at all points on the pump performance curves.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades- Tier 2
Bancroft Architects + Engineers

02-01-20

5. Motors utilized with variable frequency drives shall be rated

"inverter-duty" per NEMA MG 1, Part 31, Definite-Purpose Inverter-Fed Polyphase Motors. Provide motor shaft grounding apparatus that will protect bearings from damage from stray currents.

M. Additional requirements for specific motors, as indicated in the other sections listed in Article, RELATED SECTIONS shall also apply.

N. NEMA Premium Efficiency Electric Motors (Motor Efficiencies): All permanently wired polyphase motors of 746 W (1 hp) or more shall meet the minimum full-load efficiencies as indicated in the following table. Motors of 746 W (1 hp) or more with open, drip-proof, or TEFC enclosures shall be NEMA premium efficiency type, unless otherwise indicated. Motors provided as an integral part of motor driven equipment are excluded from this requirement if a minimum seasonal or overall efficiency requirement is indicated for that equipment by the provisions of another section.

Minimum Premium Efficiencies Open Drip-Proof				Minimum Premium Efficiencies Totally Enclosed Fan-Cooled (TEFC)			
Rating kW (hp)	1200 RPM	1800 RPM	3600 RPM	Rating kW (hp)	1200 RPM	1800 RPM	3600 RPM
0.746 (1)	82.5%	85.5%	77.0%	0.746 (1)	82.5%	85.5%	77.0%
1.12 (1.5)	86.5%	86.5%	84.0%	1.12 (1.5)	87.5%	86.5%	84.0%
1.49 (2)	87.5%	86.5%	85.5%	1.49 (2)	88.5%	86.5%	85.5%
2.24 (3)	88.5%	89.5%	85.5%	2.24 (3)	89.5%	89.5%	86.5%
3.73 (5)	89.5%	89.5%	86.5%	3.73 (5)	89.5%	89.5%	88.5%
5.60 (7.5)	90.2%	91.0%	88.5%	5.60 (7.5)	91.0%	91.7%	89.5%
7.46 (10)	91.7%	91.7%	89.5%	7.46 (10)	91.0%	91.7%	90.2%

O. Minimum Power Factor at Full Load and Rated Voltage: 90 percent at 1200 RPM, 1800 RPM, and 3600 RPM. Power factor correction capacitors shall be provided unless the motor meets the 0.90 requirement without it or if the motor is controlled by a variable frequency drive. The power factor correction capacitors shall be able to withstand high voltage transients and power line variations without breakdown.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades- Tier 2
Bancroft Architects + Engineers

02-01-20

P. Energy Efficiency of Small Motors (Motor Efficiencies): All motors under 746 W (1 hp) shall meet the requirements of the DOE Small Motor Regulation.

Polyphase Open Motors Average full load efficiency				Capacitor-start capacitor-run and capacitor-start induction run open motors Average full load efficiency			
Rating kW (hp)	6 poles	4 poles	2 poles	Rating kW (hp)	6 poles	4 poles	2 poles
0.18 (0.25)	67.5	69.5	65.6	0.18 (0.25)	62.2	68.5	66.6
0.25 (0.33)	71.4	73.4	69.5	0.25 (0.33)	66.6	72.4	70.5
0.37 (0.5)	75.3	78.2	73.4	0.37 (0.5)	76.2	76.2	72.4
0.55 (0.75)	81.7	81.1	76.8	0.55 (0.75)	80.2	81.8	76.2

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install motors in accordance with manufacturer's recommendations, the NEC, NEMA, as shown on the drawings and/or as required by other sections of these specifications.
- B. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

3.2 FIELD TESTS

- A. All tests shall be witnessed by the Commissioning Agent or by the COR.
- B. Perform an electric insulation resistance Test using a megohmmeter on all motors after installation, before startup. All shall test free from grounds.
- C. Perform Load test in accordance with IEEE 112, Test Method B, to determine freedom from electrical or mechanical defects and compliance with performance data.
- D. Insulation Resistance: Not less than one-half meg-ohm between stator conductors and frame, to be determined at the time of final inspection.
- E. All test data shall be compiled into a report form for each motor and provided to the contracting officer or their representative.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

3.3 STARTUP AND TESTING

- A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.
- B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.
- C. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.

3.4 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- B. Components provided under this section of the specification will be tested as part of a larger system.

3.5 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for one hour to instruct each VA personnel responsible in operation and maintenance of the system.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

- - - E N D - - -

SECTION 23 05 41
NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the application of noise control measures, and vibration control techniques to boiler plant rotating equipment and parts including chillers, cooling towers, boilers, pumps, fans, compressors, motors and steam turbines.
- B. A complete listing of all common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC. Noise criteria, vibration tolerance and vibration isolation for HVAC and plumbing work.

1.2 RELATED WORK

- A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA and SAMPLES.
- B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- C. Section 23 31 00, HVAC DUCTS and CASINGS.
- D. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.3 QUALITY ASSURANCE

- A. Refer to article, QUALITY ASSURANCE in specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- B. Noise Criteria:
1. Noise levels in all 8 octave bands due to equipment and duct systems shall not exceed following NC levels:

TYPE OF ROOM	NC LEVEL
Shops	50
X-Ray and General Work Rooms	40

2. For equipment which has no sound power ratings scheduled on the plans, the contractor shall select equipment such that the foregoing noise criteria, local ordinance noise levels, and OSHA requirements are not exceeded. Selection procedure shall be in accordance with ASHRAE Fundamentals Handbook, Chapter 8, Sound and Vibration.
3. An allowance, not to exceed 5db, may be added to the measured value to compensate for the variation of the room attenuating effect

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

- between room test condition prior to occupancy and design condition after occupancy which may include the addition of sound absorbing material, such as, furniture. This allowance may not be taken after occupancy. The room attenuating effect is defined as the difference between sound power level emitted to room and sound pressure level in room.
4. In absence of specified measurement requirements, measure equipment noise levels three feet from equipment and at an elevation of maximum noise generation.
- C. Allowable Vibration Tolerances for Rotating, Non-reciprocating Equipment: Not to exceed a self-excited vibration maximum velocity of 5 mm per second (0.20 inch per second) RMS, filter in, when measured with a vibration meter on bearing caps of machine in vertical, horizontal and axial directions or measured at equipment mounting feet if bearings are concealed. Measurements for internally isolated fans and motors may be made at the mounting feet.

1.4 SUBMITTALS

- A. Submit in accordance with specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
1. Vibration isolators:
 - a. Floor mountings
 - b. Hangers
 - c. Snubbers
 - d. Thrust restraints
 2. Bases.
 3. Acoustical enclosures.
- C. Isolator manufacturer shall furnish with submittal load calculations for selection of isolators, including supplemental bases, based on lowest operating speed of equipment supported.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

- B. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE):
Handbook 2017.....Fundamentals Handbook, Chapter 8, Sound and Vibration
- C. American Society for Testing and Materials (ASTM):
A123/A123M-2017.....Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
A307-2016.....Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength
D2240-05(2010).....Standard Test Method for Rubber Property - Durometer Hardness
- D. Manufacturers Standardization (MSS):
SP-58-2018.....Pipe Hangers and Supports-Materials, Design and Manufacture
- E. Occupational Safety and Health Administration (OSHA):
29 CFR 1960.95.....Occupational Noise Exposure
- F. American Society of Civil Engineers (ASCE):
ASCE 7-2017.....Minimum Design Loads for Buildings and Other Structures.
- G. American National Standards Institute / Sheet Metal and Air Conditioning Contractor's National Association (ANSI/SMACNA):
001-2008.....Seismic Restraint Manual: Guidelines for Mechanical Systems, 3rd Edition.
- H. International Code Council (ICC):
IBC 2018.....International Building Code.
- I. Department of Veterans Affairs (VA):
H-18-8 2016.....Seismic Design Requirements.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Type of isolator, base, and minimum static deflection shall be as required for each specific equipment application as recommended by isolator or equipment manufacturer but subject to minimum requirements indicated herein and in the schedule on the drawings.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

02-01-20

- B. Elastometric Isolators shall comply with ASTM D2240 and be oil resistant neoprene with a maximum stiffness of 60 durometer and have a straight-line deflection curve.
- C. Exposure to weather: Isolator housings to be either hot dipped galvanized or powder coated to ASTM B117 salt spray testing standards. Springs to be powder coated or electro galvanized. All hardware to be electro galvanized. In addition provide limit stops to resist wind velocity. Velocity pressure established by wind shall be calculated in accordance with section 1609 of the International Building Code. A minimum wind velocity of 75 mph shall be employed.
- D. Uniform Loading: Select and locate isolators to produce uniform loading and deflection even when equipment weight is not evenly distributed.
- E. Color code isolators by type and size for easy identification of capacity.

2.2 SEISMIC RESTRAINT REQUIREMENTS FOR EQUIPMENTS (NOT USED)

2.3 VIBRATION ISOLATORS

- A. Floor Mountings:
 - 1. Double Deflection Neoprene (Type N): Shall include neoprene covered steel support plated (top and bottom), friction pads, and necessary bolt holes.
 - 2. Spring Isolators (Type S): Shall be free-standing, laterally stable and include acoustical friction pads and leveling bolts. Isolators shall have a minimum ratio of spring diameter-to-operating spring height of 1.0 and an additional travel to solid equal to 50 percent of rated deflection.
 - 3. Captive Spring Mount for Seismic Restraint (Type SS):
 - a. Design mounts to resiliently resist seismic forces in all directions. Snubbing shall take place in all modes with adjustment to limit upward, downward, and horizontal travel to a maximum of 6 mm (1/4-inch) before contacting snubbers. Mountings shall have a minimum rating of one G coefficient of gravity as calculated and certified by a registered structural engineer.
 - b. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

shall have a minimum additional travel to solid equal to 50 percent of the rated deflection. Mountings shall have ports for spring inspection. Provide an all directional neoprene cushion collar around the equipment bolt.

4. Spring Isolators with Vertical Limit Stops (Type SP): Similar to spring isolators noted above, except include a vertical limit stop to limit upward travel if weight is removed and also to reduce movement and spring extension due to wind loads. Provide clearance around restraining bolts to prevent mechanical short circuiting.
 5. Pads (Type D), Washers (Type W), and Bushings (Type L): Pads shall be natural rubber or neoprene waffle, neoprene and steel waffle, or reinforced duck and neoprene. Washers and bushings shall be reinforced duck and neoprene. Washers and bushings shall be reinforced duck and neoprene. Size pads for a maximum load of 345 kPa (50 pounds per square inch).
- B. Hangers: Shall be combination neoprene and springs unless otherwise noted and shall allow for expansion of pipe.
1. Combination Neoprene and Spring (Type H): Vibration hanger shall contain a spring and double deflection neoprene element in series. Spring shall have a diameter not less than 0.8 of compressed operating spring height. Spring shall have a minimum additional travel of 50 percent between design height and solid height. Spring shall permit a 15 degree angular misalignment without rubbing on hanger box.
 2. Spring Position Hanger (Type HP): Similar to combination neoprene and spring hanger except hanger shall hold piping at a fixed elevation during installation and include a secondary adjustment feature to transfer load to spring while maintaining same position.
 3. Neoprene (Type HN): Vibration hanger shall contain a double deflection type neoprene isolation element. Hanger rod shall be separated from contact with hanger bracket by a neoprene grommet.
 4. Spring (Type HS): Vibration hanger shall contain a coiled steel spring in series with a neoprene grommet. Spring shall have a diameter not less than 0.8 of compressed operating spring height. Spring shall have a minimum additional travel of 50 percent between

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

design height and solid height. Spring shall permit a 15 degree angular misalignment without rubbing on hanger box.

5. Hanger supports for piping 50 mm (2 inches) and larger shall have a pointer and scale deflection indicator.
6. Hangers used in seismic applications shall be provided with a neoprene and steel rebound washer installed ¼' clear of bottom of hanger housing in operation to prevent spring from excessive upward travel.

2.4 BASES (NOT USED)

2.5 SOUND ATTENUATING UNITS (NOT USED)

2.6 ACOUSTICAL ENCLOSURES IN MECHANICAL ROOMS (NOT USED)

PART 3 - EXECUTION

3.1 INSTALLATION

A. Vibration Isolation:

1. No metal-to-metal contact will be permitted between fixed and floating parts.
2. Connections to Equipment: Allow for deflections equal to or greater than equipment deflections. Electrical, drain, piping connections, and other items made to rotating or reciprocating equipment (pumps, compressors, etc.) which rests on vibration isolators, shall be isolated from building structure for first three hangers or supports with a deflection equal to that used on the corresponding equipment.
3. Common Foundation: Mount each electric motor on same foundation as driven machine. Hold driving motor and driven machine in positive rigid alignment with provision for adjusting motor alignment and belt tension. Bases shall be level throughout length and width. Provide shims to facilitate pipe connections, leveling, and bolting.
4. Provide heat shields where elastomers are subject to temperatures over 38 degrees C (100 degrees F).

- B. Inspection and Adjustments: Check for vibration and noise transmission through connections, piping, ductwork, foundations, and walls. Adjust, repair, or replace isolators as required to reduce vibration and noise transmissions to specified levels.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

02-01-20

3.2 ADJUSTING

- A. Adjust vibration isolators after piping systems are filled and equipment is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Adjust active height of spring isolators.
- D. Torque anchor bolts according to equipment manufacturer's recommendations to resist seismic forces.

3.3 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

- - - E N D - - -

01/16/2024

Fargo VA Health Care System
Fargo, ND 58102
EHRM Infrastructure Upgrades

Bancroft Architects + Engineers

02-01-20

SELECTION GUIDE FOR VIBRATION ISOLATORS

EQUIPMENT	ON GRADE			20FT FLOOR SPAN			30FT FLOOR SPAN			40FT FLOOR SPAN			50FT FLOOR SPAN		
	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL
REFRIGERATION MACHINES															
ABSORPTION	---	D	0.3	---	SP	0.8	---	SP	1.5	---	SP	1.5	---	SP	2.0
PACKAGED HERMETIC	---	D	0.3	---	SP	0.8	---	SP	1.5	---	SP	1.5	R	SP	2.5
OPEN CENTRIFUGAL	B	D	0.3	B	SP	0.8	---	SP	1.5	B	SP	1.5	B	SP	3.5
RECIPROCATING:															
ALL	---	D	0.3	---	SP	0.8	R	SP	2.0	R	SP	2.5	R	SP	3.5
ROOF FANS															
ABOVE OCCUPIED AREAS:															
5 HP & OVER	---	---	---	CB	S	1.0	CB	S	1.0	CB	S	1.0	CB	S	1.0
CENTRIFUGAL FANS															
UP TO 50 HP:															
UP TO 200 RPM	B	N	0.3	B	S	2.5	B	S	2.5	B	S	3.5	B	S	3.5
201 - 300 RPM	B	N	0.3	B	S	2.0	B	S	2.5	B	S	2.5	B	S	3.5
301 - 500 RPM	B	N	0.3	B	S	2.0	B	S	2.0	B	S	2.5	B	S	3.5
501 RPM & OVER	B	N	0.3	B	S	2.0	B	S	2.0	B	S	2.0	B	S	2.5

Contract No. 36C26319D0044
Station Project No. 437-21-205
Bancroft-AE Project No. 18-121

2/2/22

23 05 41 - 1

Noise and Vibration Control for HVAC Piping and Equipment

Fargo VA Health Care System
 Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
 Bancroft Architects + Engineers

02-01-20

EQUIPMENT	ON GRADE			20FT FLOOR SPAN			30FT FLOOR SPAN			40FT FLOOR SPAN			50FT FLOOR SPAN		
	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL
AIR HANDLING UNIT PACKAGES															
SUSPENDED:															
UP THRU 5 HP	---	---	---	---	H	1.0	---	H	1.0	---	H	1.0	---	H	1.0
7-1/2 HP & OVER:															
UP TO 500 RPM	---	---	---	---	H, THR	1.5	---	H, THR	2.5	---	H, THR	2.5	---	H, THR	2.5
501 RPM & OVER	---	---	---	---	H, THR	0.8	---	H, THR	0.8	---	H,TH R	0.8	---	H,TH R	2.0
CONDENSING UNITS															
ALL	---	SS	0.25	---	SS	0.75	---	SS	1.5	CB	SS	1.5	---	---	NA
IN-LINE CENTRIFUGAL AND VANE AXIAL FANS, FLOOR MOUNTED: (APR 9)															
UP THRU 50 HP:															
UP TO 300 RPM	---	D	---	R	S	2.5	R	S	2.5	R	S	2.5	R	S	3.5
301 - 500 RPM	---	D	---	R	S	2.0	R	S	2.0	R	S	2.5	R	S	2.5
501 - & OVER	---	D	---	---	S	1.0	---	S	1.0	R	S	2.0	R	S	2.5
60 HP AND OVER:															
301 - 500 RPM	R	S	1.0	R	S	2.0	R	S	2.0	R	S	2.5	R	S	3.5
501 RPM & OVER	R	S	1.0	R	S	2.0	R	S	2.0	R	S	2.0	R	S	2.5

Contract No. 36C26319D0044
 Station Project No. 437-21-210
 Bancroft-AE Project No. 22-113

01/16/2024

23 05 41 - 2

Noise and Vibration Control for HVAC Piping and Equipment

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

02-01-20

NOTES:

1. Edit the Table above to suit where isolator, other than those shown, are used, such as for seismic restraints and position limit stops.
2. For suspended floors lighter than 100 mm (4 inch) thick concrete, select deflection requirements from next higher span.
3. For separate chiller building on grade, pump isolators may be omitted.
4. Direct bolt fire pumps to concrete base. Provide pads (D) for domestic water booster pump package.
5. For projects in seismic areas, use only SS & DS type isolators and snubbers.
6. For floor mounted in-line centrifugal blowers (ARR 1): use "B" type in lieu of "R" type base.
7. Suspended: Use "H" isolators of same deflection as floor mounted.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

23 05 41 - 3

Noise and Vibration Control for HVAC Piping and Equipment

SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

- A. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Testing, adjusting, and balancing (TAB) of heating, ventilating and air conditioning (HVAC) systems. TAB includes the following:
 - 1. Planning systematic TAB procedures.
 - 2. Design Review Report.
 - 3. Systems Inspection Report.
 - 4. Duct Air Leakage Test Report.
 - 5. Systems Readiness Report.
 - 6. Balancing air and water distribution systems; adjustment of total system to provide design performance; and testing performance of equipment and automatic controls.
 - 7. Vibration and sound measurements.
 - 8. Recording and reporting results.
 - 9. Document critical paths of flow on reports.
- C. Definitions:
 - 1. Basic TAB used in this Section: Chapter 39, "Testing, Adjusting and Balancing" of ASHRAE Handbook "HVAC Applications".
 - 2. TAB: Testing, Adjusting and Balancing; the process of checking and adjusting HVAC systems to meet design objectives.
 - 3. AABC: Associated Air Balance Council.
 - 4. NEBB: National Environmental Balancing Bureau.
 - 5. TABB: Testing Adjusting and Balancing Bureau.
 - 6. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.
 - 7. Hydronic Systems: Includes heating hot water, and glycol-water systems.
 - 8. Air Systems: Includes all outside air, supply air, return air, exhaust air and relief air systems.
 - 9. Flow Rate Tolerance: The allowable percentage variation, minus to plus, of actual flow rate from values (design) in the contract documents.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
- E. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT and STEAM GENERATION.
- F. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- G. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- H. Section 23 07 11, HVAC AND BOILER PLANT INSULATION.
- I. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- J. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- K. Section 23 31 00, HVAC DUCTS AND CASINGS.
- L. Section 23 36 00, AIR TERMINAL UNITS.

1.3 APPLICABLE PUBLICATIONS

- A. The following publications form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standards will govern.
- B. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE):
2019.....ASHRAE Handbook - HVAC Applications, Chapter 39, Testing, Adjusting, and Balancing and Chapter 49, Noise and Vibration Control
- C. Associated Air Balance Council (AABC):
2016.....National Standards for Total System Balance, 7th Edition
- D. National Environmental Balancing Bureau (NEBB):
2019.....Procedural Standard for Testing, Adjusting, and Balancing of Environmental Systems, 9th Edition
2015.....Procedural Standard for the Measurement of Sound and Vibration, 2nd Edition
S110-2019.....Whole Building Technical Commissioning of New Construction, 2nd Edition

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- E. Sheet Metal and Air Conditioning Contractors National Association
(SMACNA):
2002.....HVAC Systems Testing, Adjusting and Balancing,
3rd Edition
2003.....TAB Procedural Guide 1st Edition

1.4 SUBMITTALS

- A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION XX XX XX, SECTION TITLE", with applicable paragraph identification.
- C. Submit names and qualifications of TAB agency and TAB Specialists within 60 days after the notice to proceed. Submit information on three recently completed projects and a list of proposed test equipment.
- D. For use by the COR staff, submit one complete set of applicable AABC, NEBB or TABB publications that will be the basis of TAB work.
- E. Submit the following for review and approval:
1. Design Review Report within 90 days for conventional design projects after the system layout on air and water side is completed by the Contractor.
 2. Systems inspection report on equipment and installation for conformance with design.
 3. Duct Air Leakage Test Report.
 4. Systems Readiness Report.
 5. Intermediate and Final TAB reports covering flow balance and adjustments, performance tests, vibration tests and sound tests.
 6. Include in final reports uncorrected installation deficiencies noted during TAB and applicable explanatory comments on test results that differ from design requirements.
 7. Include in each report the critical path for each balanced branch (air and hydronic). Every branch shall have at least one terminal device damper 100 percent open.
- F. Prior to request for Final or Partial Final inspection, submit completed Test and Balance report for the area with noted critical paths.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

1.5 QUALITY ASSURANCE

A. Refer to paragraphs QUALITY ASSURANCE and SUBMITTALS, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC, Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT and STEAM GENERATION, and Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

B. Qualifications:

1. TAB Agency: The TAB agency shall be a subcontractor of the General Contractor and shall report to and be paid by the General Contractor.
2. The TAB agency shall be either a certified member of AABC, NEBB, or TABB to perform TAB service for HVAC, water balancing and vibrations and sound testing of equipment. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the agency loses subject certification during this period, the General Contractor shall immediately notify the COR and submit another qualified TAB firm for approval. Any agency that has been the subject of disciplinary action by either the AABC, TABB or NEBB within the five (5) years preceding Contract Award shall not be eligible to perform any work related to the TAB. All work performed in this Section and in other related Sections by the TAB agency shall be considered invalid if the TAB agency loses its certification prior to Contract completion, and the successor agency's review shows unsatisfactory work performed by the predecessor agency.
3. TAB Specialist: The TAB Specialist shall be either a member of AABC or TABB or an experienced technician of the Agency certified by NEBB. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, the General Contractor shall immediately notify the COR and submit another TAB Specialist for approval. Any individual that has been the subject of disciplinary action by either the AABC or the NEBB within the five (5) years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections performed by the TAB Specialist shall be considered invalid if the TAB Specialist

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- loses its certification prior to Contract completion and shall be performed by an approved successor.
4. TAB Specialist shall be identified by the General Contractor within sixty (60) days after the Notice to Proceed. The TAB Specialist will be coordinating, scheduling, and reporting all TAB work and related activities and will provide necessary information as required by the COR. The responsibilities shall specifically include:
- a. Directly supervising all TAB work.
 - b. Sign the TAB reports that bear the seal of the TAB standard. The reports shall be accompanied by report forms and schematic drawings required by the TAB standard, AABC, TABB or NEBB.
 - c. Following all TAB work through its satisfactory completion.
 - d. Providing final markings of settings of all HVAC adjustment devices.
 - e. Permanently mark location of duct test ports.
 - f. Documenting critical paths from the fan or pump. These critical paths are ones in which are 100 percent open from the fan or pump to the terminal device. This will show the least amount of restriction is being imposed on the system by the TAB firm.
5. All TAB technicians performing actual TAB work shall be experienced and shall have done satisfactory work on a minimum of three (3) projects comparable in size and complexity to this project. Qualifications shall be certified by the TAB agency in writing. The lead technician shall be certified by AABC, TABB or NEBB.
- C. Test Equipment Criteria: The instrumentation shall meet the accuracy/calibration requirements established by AABC National Standards, TABB/SMACNA International Standards, or by NEBB Procedural Standard for Testing, Adjusting and Balancing of Environmental Systems and instrument manufacturer. Provide calibration history of the instruments to be used for test and balance purpose. All equipment shall remain in calibration, or be re-calibrated if certification expires, during the TAB procedures.
- D. TAB Criteria:
- 1. One or more of the applicable AABC, NEBB, TABB or SMACNA publications, supplemented by Chapter 39, "Testing, Adjusting and Balancing" of ASHRAE Handbook "HVAC Applications" and requirements

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

stated herein shall be the basis for planning, procedures, and reports.

2. Flow Rate Tolerance: Following tolerances are allowed. For tolerances not mentioned herein follow Chapter 39, "Testing, Adjusting and Balancing" of ASHRAE Handbook "HVAC Applications" as a guideline. Air Filter resistance during tests, artificially imposed, if necessary, shall be at least 100 percent of manufacturer recommended change over pressure drop values for pre-filters and after-filters.
 - a. Air handling unit and all other fans, cubic meters/min (cubic feet per minute): Minus 5 percent to plus 10 percent.
 - b. Air Terminal Units (maximum values): Minus 5 percent to plus 10 percent
 - c. Minimum Outside Air: 0 percent to plus 10 percent.
 - d. Individual room air outlets and inlets, and air flow rates not mentioned above: Minus 5 percent to plus 10 percent except if the air to air space is 100 CFM or less the tolerance will be minus 5 to plus 5 percent.
 - e. Chilled Water Coils: Minus 5 percent to plus 5 percent.
3. Systems shall be adjusted for energy efficient operation as described in PART 3.
4. Typical TAB procedures and critical path results shall be demonstrated to the COR for one air distribution system (including all fans, 3 terminal units, 3 rooms randomly selected by the COR, one of which shall be a critical path) and 1 hydronic system (pumps and 3 coils) as follows:
 - a. When field TAB work begins.
 - b. During each partial final inspection and the final inspection for the project if requested by VA.

PART 2 - PRODUCTS

2.1 PLUGS

- A. Provide plastic plugs to seal holes drilled in ductwork for test purposes.

2.2 INSULATION REPAIR MATERIAL

- A. See Section 23 07 11, HVAC and BOILER PLANT INSULATION. Provide for repair of insulation removed or damaged for TAB work.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

PART 3 - EXECUTION

3.1 GENERAL

- A. Refer to TAB Criteria in Paragraph QUALITY ASSURANCE.
- B. Obtain applicable contract documents and copies of approved submittals for HVAC equipment and automatic control systems.

3.2 DESIGN REVIEW REPORT

- A. The TAB Specialist shall review the contract documents and advise the COR of any design deficiencies that would prevent the HVAC systems from effectively operating in accordance with the sequence of operation specified or prevent the effective and accurate TAB of the system. The TAB Specialist shall provide a report individually listing each deficiency and the corresponding proposed corrective action necessary for proper system operation.

3.3 SYSTEMS INSPECTION REPORT

- A. Inspect equipment and installation for conformance with design.
- B. The inspection and report shall be done after air distribution and hydronic equipment is onsite and duct and piping installation has begun, but well in advance of performance testing and balancing work. The purpose of the inspection is to identify and report deviations from design and ensure that systems will be ready for TAB at the appropriate time.
- C. Reports: Follow checklist format developed by AABC, NEBB or SMACNA (TABB), supplemented by narrative comments, with emphasis on air-handling units and fans. Check for conformance with submittals. Verify that diffuser and register sizes are correct. Check air terminal unit installation including their duct sizes and routing.

3.4 DUCT AIR LEAKAGE TEST REPORT

- A. TAB Agency shall perform the leakage test as outlined in "Duct Leakage Tests and Repairs" in Section 23 31 00, HVAC DUCTS and CASINGS for TAB agency's role and responsibilities in witnessing, recording and reporting of deficiencies.

3.5 SYSTEM READINESS REPORT

- A. The TAB Contractor shall measure existing air and water flow rates associated with existing systems utilized to serve renovated areas as indicated in the contract documents. Submit report of findings to COR.

03-01-23

- B. Inspect each system to ensure that it is complete including installation and operation of controls. Submit report to COR in standard format and forms prepared and/or approved by the CxA.
- C. Verify that all items such as ductwork piping, dampers, valves, ports, terminals, connectors, etc., that are required for TAB are installed. Provide a report to the COR.

3.6 TAB REPORTS

- A. Submit an intermediate report for 50 percent of systems and equipment tested and balanced to establish satisfactory test results.
- B. The TAB Contractor shall provide raw data immediately in writing to the COR if there is a problem in achieving intended results before submitting a formal report.
- C. If over 20 percent of readings in the intermediate report fall outside the acceptable range, the TAB report shall be considered invalid and all contract TAB work shall be repeated after engineering and construction have been evaluated and re-submitted for approval at no additional cost to the owner.
- D. Do not proceed with the remaining systems until intermediate report is approved by the COR.

3.7 TAB PROCEDURES

- A. TAB shall be performed in accordance with the requirement of the Standard under which TAB agency is certified by either AABC, TABB or NEBB. Balancing shall be done proportionally to all applicable systems.
 - 1. At least 1 trunk damper shall be 100 percent open.
 - 2. At least 1 branch damper shall be 100 percent open per trunk.
 - 3. At least 1 terminal device duct be 100 percent open per branch.
 - 4. At least one hydronic balancing valve shall be 100 percent open per hydronic system.
- B. General: During TAB all related system components shall be in full operation. Fan and pump rotation, motor loads and equipment vibration shall be checked and corrected as necessary before proceeding with TAB. Set controls and/or block off parts of distribution systems to simulate design operation of variable volume air or water systems for test and balance work.
- C. Coordinate TAB procedures with existing systems and any phased construction completion requirements for the project. Provide TAB

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

reports for each phase of the project prior to partial final inspections of each phase of the project. Return existing areas outside the work area to pre-constructed conditions.

- D. Allow 5 days' time in construction schedule for TAB and submission of all reports for an organized and timely correction of deficiencies.
- E. Air Balance and Equipment Test: Include air-handling units, fans, terminal units, fan coil units, room diffusers/outlets/inlets, computer room AC units, and laboratory fume hoods and biological safety cabinets.
 - 1. Artificially load air filters by partial blanking to produce static air pressure drop of manufacturer's recommended pressure drop.
 - 2. Adjust fan speeds to provide design air flow. V-belt drives, including fixed pitch pulley requirements, are specified in Section 23 05 11, COMMON WORK RESULTS FOR HVAC Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT and STEAM GENERATION. Provide new drive sets as required to adjust fan speeds.
 - 3. Test and balance systems in all specified modes of operation, including variable volume, economizer, and fire emergency modes. Verify that dampers and other HVAC controls function properly.
 - 4. Variable Air Volume (VAV) Systems:
 - a. Coordinate TAB, including system volumetric controls, with Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
 - b. Section 23 36 00, AIR TERMINAL UNITS, specifies that maximum and minimum flow rates for air terminal units (ATU) be factory set. Check and readjust ATU flow rates if necessary to meet design criteria. Balance air distribution from ATU on full cooling maximum scheduled cubic meters per minute (cubic feet per minute). Reset room thermostats and check ATU operation from maximum to minimum cooling, to the heating mode, and back to cooling. Record and report the heating coil leaving air temperature when the ATU is in the maximum heating mode. Record and report outdoor air flow rates under all operating conditions (The test shall demonstrate that the minimum outdoor air ventilation rate shall remain constant under all operating conditions).

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- c. Adjust operating pressure control setpoint to maintain the design flow to each space with the lowest setpoint. Confirm static pressure reset is operational and functioning properly.
- 5. Record final measurements for air handling equipment performance data sheets.
- 6. Record final damper settings for all manual volume dampers.

3.8 VIBRATION TESTING

- A. Furnish instruments and perform vibration measurements as specified in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT. Field vibration balancing is specified in Section 23 05 11, COMMON WORK RESULTS FOR HVAC Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT and STEAM GENERATION. Provide measurements for all rotating HVAC equipment of 373 watts (1/2 horsepower) and larger, including centrifugal/screw compressors, cooling towers, pumps, fans and motors.
- B. Record initial measurements for each unit of equipment on test forms and submit a report to the COR. Where vibration readings exceed the allowable tolerance Contractor shall be directed to correct the problem. The TAB agency shall verify that the corrections are done and submit a final report to the COR.

3.9 SOUND TESTING

- A. Perform and record required sound measurements in accordance with paragraph QUALITY ASSURANCE in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
 - 1. Take readings in rooms, approximately fifteen (15) percent of all rooms. The COR may designate the specific rooms to be tested.
- B. Take measurements with a calibrated sound level meter and octave band analyzer of the accuracy required by AABC, TABB or NEBB.
- C. Sound reference levels, formulas and coefficients shall be according to ASHRAE Handbook "HVAC Applications", Chapter 49, "Noise and Vibration Control".
- D. Determine compliance with contract documents as follows:
 - 1. When sound pressure levels are specified, including the NC Criteria in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT:

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- a. Reduce the background noise as much as possible by shutting off unrelated audible equipment.
- b. Measure octave band sound pressure levels with specified equipment "off."
- c. Measure octave band sound pressure levels with specified equipment "on."
- d. Use the DIFFERENCE in corresponding readings to determine the sound pressure due to equipment.

DIFFERENCE:	0	1	2	3	4	5 to 9	10 or More
FACTOR:	10	7	4	3	2	1	0

Sound pressure level due to equipment equals sound pressure level with equipment "on" minus FACTOR.

- e. Plot octave bands of sound pressure level due to equipment for typical rooms on a graph which also shows noise criteria (NC) curves.
2. When sound power levels are specified:
 - a. Perform steps 1.a. through 1.d., as specified above.
 - b. For Indoor Equipment: Determine room attenuating effect, i.e., difference between sound power level and sound pressure level. Determined sound power level will be the sum of sound pressure level due to equipment plus the room attenuating effect.
 - c. For Outdoor Equipment: Use directivity factor and distance from noise source to determine distance factor, i.e., difference between sound power level and sound pressure level. Measured sound power level will be the sum of sound pressure level due to equipment plus the distance factor. Use 9 meters (30 feet) for sound level location.
 3. Where sound pressure levels are specified in terms of dB(A), as in Section 23 65 00, COOLING TOWERS, measure sound levels using the "A" scale of meter. Single value readings will be used instead of octave band analysis.
- E. Where measured sound levels exceed specified level, the installing contractor or equipment manufacturer shall take remedial action approved by the COR and the necessary sound tests shall be repeated.

- F. Test readings for sound testing could go higher than 15 percent if determination is made by the COR based on the recorded sound data.

3.10 MARKING OF SETTINGS

- A. Following approval of TAB Final Report, the setting of all HVAC adjustment devices including valves, splitters and dampers shall be permanently marked by the TAB Specialist so that adjustment can be restored if disturbed at any time. Style and colors used for markings shall be coordinated with the COR.

3.11 IDENTIFICATION OF TEST PORTS

- A. The TAB Specialist shall permanently and legibly identify the location points of duct test ports. If the ductwork has exterior insulation, the identification shall be made on the exterior side of the insulation. All penetrations through ductwork and ductwork insulation shall be sealed to prevent air leaks and maintain integrity of vapor barrier.

3.12 PHASING

- A. Phased Projects: Testing and Balancing Work to follow project with areas shall be completed per the project phasing. Upon completion of the project all areas shall have been tested and balanced per the contract documents.
- B. Existing Areas: Systems that serve areas outside of the project scope shall not be adversely affected. Measure existing parameters where shown to document system capacity.

3.13 CRITICAL FLOW PATH

- A. Provide a documented critical path for all fluid flows. There shall be at least one (1) terminal device that can be traced back to the fan or pump where there is no damper or valves that are less than 100 percent open.

3.14 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- B. Components provided under this section of the specification will be tested as part of a larger system.

- - E N D - -

SECTION 23 07 11
HVAC AND BOILER PLANT INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Field applied insulation for thermal efficiency and condensation control for
1. HVAC piping, ductwork and equipment.
 2. Re-insulation of HVAC piping, ductwork and equipment, and boiler plant piping, breeching and stacks and equipment after asbestos abatement.
- B. Definitions
1. ASJ: All service jacket, white finish facing or jacket.
 2. Air conditioned space: Space having air temperature and/or humidity controlled by mechanical equipment.
 3. Cold: Equipment, ductwork or piping handling media at design temperature of 16 degrees C (60 degrees F) or below.
 4. Concealed: Ductwork above ceilings and in chases, interstitial space, and pipe spaces.
 5. Exposed: Ductwork, and equipment exposed to view in finished areas including mechanical, and electrical equipment rooms or exposed to outdoor weather. Attics and crawl spaces where air handling units are located are considered to be mechanical rooms. Shafts, chases, interstitial spaces, unfinished attics, crawl spaces and pipe basements are not considered finished areas.
 6. FSK: Foil-scrim-kraft facing.
 7. Hot: HVAC Ductwork handling air at design temperature above 16 degrees C (60 degrees F).
 8. Density: kg/m³ - kilograms per cubic meter (Pcf - pounds per cubic foot).
 9. Runouts: Branch pipe connections up to 25-mm (one-inch) nominal size to fan coil units or reheat coils for terminal units.
 10. Thermal conductance: Heat flow rate through materials.
 - a. Flat surface: Watt per square meter (BTU per hour per square foot).
 - b. Pipe or Cylinder: Watt per square meter (BTU per hour per linear foot).

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
Bancroft Architects + Engineers

02-01-20

11. Thermal Conductivity (k): Watt per meter, per degree C (BTU per inch thickness, per hour, per square foot, per degree F temperature difference).
12. Vapor Retarder (Vapor Barrier): A material which retards the transmission (migration) of water vapor. Performance of the vapor retarder is rated in terms of permeance (perms). For the purpose of this specification, vapor retarders shall have a maximum published permeance of 0.1 perms and vapor barriers shall have a maximum published permeance of 0.001 perms.
13. R: Pump recirculation.
14. FOS: Fuel oil supply.
15. FOR: Fuel oil return.
16. CW: Cold water.
17. HW: Hot water.
18. CH: Chilled water supply.
19. CHR: Chilled water return.
20. RS: Refrigerant suction.

1.2 RELATED WORK

- A Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- C. Section 02 82 13. GLOVEBAG ASBESTOS ABATEMENT.
- B. Section 07 84 00, FIRESTOPPING.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.3 QUALITY ASSURANCE

- A. Refer to article QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC and Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT and STEAM GENERATION.

B. Criteria:

1. Comply with NFPA 90A, particularly paragraphs 4.3.3.1 through 4.3.3.6, 4.3.10.2.6, and 5.4.6.4, parts of which are quoted as follows:

4.3.3.1 Pipe insulation and coverings, duct coverings, duct linings, vapor retarder facings, adhesives, fasteners, tapes, and supplementary materials added to air ducts, plenums, panels, and duct silencers used in duct systems, unless otherwise provided for in 4.3.3.1.1 or 4.3.3.1.2., shall have, in the form in which they are used, a maximum flame spread index of 25 without evidence of continued progressive combustion and a maximum smoke

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
Bancroft Architects + Engineers

02-01-20

developed index of 50 when tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*.

4.3.3.1.1 Where these products are to be applied with adhesives, they shall be tested with such adhesives applied, or the adhesives used shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when in the final dry state. (See 4.2.4.2.)

4.3.3.1.2 The flame spread and smoke developed index requirements of 4.3.3.1.1 shall not apply to air duct weatherproof coverings where they are located entirely outside of a building, do not penetrate a wall or roof, and do not create an exposure hazard.

4.3.3.2 Closure systems for use with rigid and flexible air ducts tested in accordance with UL 181, Standard for Safety Factory-Made Air Ducts and Air Connectors, shall have been tested, listed, and used in accordance with the conditions of their listings, in accordance with one of the following:

(1) UL 181A, Standard for Safety Closure Systems for Use with Rigid Air Ducts and Air Connectors

(2) UL 181B, Standard for Safety Closure Systems for Use with Flexible Air Ducts and Air Connectors

4.3.3.3 Air duct, panel, and plenum coverings and linings, and pipe insulation and coverings shall not flame, glow, smolder, or smoke when tested in accordance with a similar test for pipe covering, ASTM C 411, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation, at the temperature to which they are exposed in service.

4.3.3.3.1 In no case shall the test temperature be below 121°C (250°F).

4.3.3.4 Air duct coverings shall not extend through walls or floors that are required to be fire stopped or required to have a fire resistance rating, unless such coverings meet the requirements of 5.4.6.4.

4.3.3.5* Air duct linings shall be interrupted at fire dampers to prevent interference with the operation of devices.

4.3.3.6 Air duct coverings shall not be installed so as to conceal or prevent the use of any service opening.

4.3.10.2.6 Materials exposed to the airflow shall be noncombustible or limited combustible and have a maximum smoke developed index of 50 or comply with the following.

4.3.10.2.6.1 Electrical wires and cables and optical fiber cables shall be listed as noncombustible or limited combustible and have a maximum smoke developed index of 50 or shall be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.5 m (5 ft) or less when tested in accordance with NFPA 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
Bancroft Architects + Engineers

02-01-20

4.3.10.2.6.2 Pneumatic tubing for control systems shall be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.5 m (5 ft) or less when tested in accordance with UL 1820, Standard for Safety Fire Test of Pneumatic Tubing for Flame and Smoke Characteristics.

4.3.10.2.6.4 Optical-fiber and communication raceways shall be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.5 m (5 ft) or less when tested in accordance with UL 2024, Standard for Safety Optical-Fiber Cable Raceway.

4.3.10.2.6.6 Supplementary materials for air distribution systems shall be permitted when complying with the provisions of 4.3.3.

5.4.6.4 Where air ducts pass through walls, floors, or partitions that are required to have a fire resistance rating and where fire dampers are not required, the opening in the construction around the air duct shall be as follows:

(1) Not exceeding a 25.4 mm (1 in.) average clearance on all sides

(2) Filled solid with an approved material capable of preventing the passage of flame and hot gases sufficient to ignite cotton waste when subjected to the time-temperature fire conditions required for fire barrier penetration as specified in NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials*

2. Test methods: ASTM E84, UL 723, or NFPA 255.

3. Specified k factors are at 24 degrees C (75 degrees F) mean temperature unless stated otherwise. Where optional thermal insulation material is used, select thickness to provide thermal conductance no greater than that for the specified material. For pipe, use insulation manufacturer's published heat flow tables. For domestic hot water supply and return, run out insulation and condensation control insulation, no thickness adjustment need be made.

4. All materials shall be compatible and suitable for service temperature, and shall not contribute to corrosion or otherwise attack surface to which applied in either the wet or dry state.

C. Every package or standard container of insulation or accessories delivered to the job site for use must have a manufacturer's stamp or label giving the name of the manufacturer and description of the material.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Shop Drawings:
 - 1. All information, clearly presented, shall be included to determine compliance with drawings and specifications and ASTM, federal and military specifications.
 - a. Insulation materials: Specify each type used and state surface burning characteristics.
 - b. Insulation facings and jackets: Each type used. Make it clear that white finish will be furnished for exposed ductwork, casings and equipment.
 - c. Insulation accessory materials: Each type used.
 - d. Manufacturer's installation and fitting fabrication instructions for flexible unicellular insulation.
 - e. Make reference to applicable specification paragraph numbers for coordination.

1.5 STORAGE AND HANDLING OF MATERIAL

Store materials in clean and dry environment, pipe covering jackets shall be clean and unmarred. Place adhesives in original containers. Maintain ambient temperatures and conditions as required by printed instructions of manufacturers of adhesives, mastics and finishing cements.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.
- B. Federal Specifications (Fed. Spec.):
 - L-P-535E (2)- 1999.....Plastic Sheet (Sheeting): Plastic Strip; Poly (Vinyl Chloride) and Poly (Vinyl Chloride - Vinyl Acetate), Rigid.
- C. Military Specifications (Mil. Spec.):
 - MIL-A-3316C -1987 Adhesives, Fire-Resistant, Thermal Insulation
 - MIL-A-24179A (1)-2016 Adhesive, Flexible Unicellular-Plastic Thermal Insulation

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
Bancroft Architects + Engineers

02-01-20

MIL-C-19565C (1)- 2016 Coating Compounds, Thermal Insulation, Fire-and
Water-Resistant, Vapor-Barrier

MIL-C-20079H-1987 Cloth, Glass; Tape, Textile Glass; and Thread,
Glass and Wire-Reinforced Glass

D. American Society for Testing and Materials (ASTM):

A167-99 2014.....Standard Specification for Stainless and
Heat-Resisting Chromium-Nickel Steel Plate,
Sheet, and Strip

B209-2014.....Standard Specification for Aluminum and
Aluminum-Alloy Sheet and Plate

C411-2019.....Standard test method for Hot-Surface
Performance of High-Temperature Thermal
Insulation

C449-2019.....Standard Specification for Mineral Fiber
Hydraulic-Setting Thermal Insulating and
Finishing Cement

C533-2017.....Standard Specification for Calcium Silicate
Block and Pipe Thermal Insulation

C534-2017.....Standard Specification for Preformed Flexible
Elastomeric Cellular Thermal Insulation in
Sheet and Tubular Form

C547-2017.....Standard Specification for Mineral Fiber pipe
Insulation

C552-07 Standard Specification for Cellular Glass
Thermal Insulation

C553-2015.....Standard Specification for Mineral Fiber
Blanket Thermal Insulation for Commercial and
Industrial Applications

C585-2016.....Standard Practice for Inner and Outer Diameters
of Rigid Thermal Insulation for Nominal Sizes
of Pipe and Tubing (NPS System) R (1998)

C612-2014.....Standard Specification for Mineral Fiber Block
and Board Thermal Insulation

C1126- 2019.....Standard Specification for Faced or Unfaced
Rigid Cellular Phenolic Thermal Insulation

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
Bancroft Architects + Engineers

02-01-20

- C1136- 2017.....Standard Specification for Flexible, Low
Permeance Vapor Retarders for Thermal
Insulation
- D1668-97a 2017.....Standard Specification for Glass Fabrics (Woven
and Treated) for Roofing and Waterproofing
- E84-2014.....Standard Test Method for Surface Burning
Characteristics of Building
Materials
- E119-2007.....Standard Test Method for Fire Tests of Building
Construction and Materials
- E136-2019.....Standard Test Methods for Behavior of Materials
in a Vertical Tube Furnace at 750 degrees C
(1380 F)
- E. National Fire Protection Association (NFPA):
- 90A-2018.....Standard for the Installation of Air
Conditioning and Ventilating Systems
- 96-2018.....Standards for Ventilation Control and Fire
Protection of Commercial Cooking Operations
- 101-2018.....Life Safety Code
- 251-2014.....Standard methods of Tests of Fire Endurance of
Building Construction Materials
- 255-2006.....Standard Method of tests of Surface Burning
Characteristics of Building Materials
- F. Underwriters Laboratories, Inc (UL):
- 723-2018.....UL Standard for Safety Test for Surface Burning
Characteristics of Building Materials with
Revision of 09/08
- G. Manufacturer's Standardization Society of the Valve and Fitting
Industry (MSS):
- SP58-2018.....Pipe Hangers and Supports Materials, Design,
and Manufacture

PART 2 - PRODUCTS

2.1 MINERAL FIBER OR FIBER GLASS

- A. ASTM C612 (Board, Block), Class 1 or 2, density 48 kg/m³ (3 pcf), k =
0.037 (0.26) at 24 degrees C (75 degrees F), external insulation for

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
Bancroft Architects + Engineers

02-01-20

temperatures up to 204 degrees C (400 degrees F) with foil scrim (FSK) facing.

- B. ASTM C553 (Blanket, Flexible) Type I, Class B-3, Density 16 kg/m³ (1 pcf), k = 0.045 (0.31) Class B-5, Density 32 kg/m³ (2 pcf), k = 0.04 (0.27) at 24 degrees C (75 degrees F).
- C. ASTM C547 (Pipe Fitting Insulation and Preformed Pipe Insulation), Class 1, k = 0.037 (0.26) at 24 degrees C (75 degrees F), for use at temperatures up to 230 degrees C (450 degrees F) with an all service vapor retarder jacket with polyvinyl chloride premolded fitting covering.

2.2 MINERAL WOOL OR REFRACTORY FIBER

- A. Comply with Standard ASTM C612, Class 3, 450 degrees C (850 degrees F).

2.3 RIGID CELLULAR PHENOLIC FOAM

- A. Preformed (molded) pipe insulation, ASTM C1126, type III, grade 1, k = 0.021(0.15) at 10 degrees C (50 degrees F), for use at temperatures up to 121 degrees C (250 degrees F) with all service vapor retarder jacket with polyvinyl chloride premolded fitting covering.
- B. Equipment and Duct Insulation, ASTM C 1126, type II, grade 1, k = 0.021 (0.15) at 10 degrees C (50 degrees F), for use at temperatures up to 121 degrees C (250 degrees F) with rigid cellular phenolic insulation and covering, and all service vapor retarder jacket.

2.4 CELLULAR GLASS CLOSED-CELL

- A. Comply with Standard ASTM C177, C518, density 120 kg/m³ (7.5 pcf) nominal, k = 0.033 (0.29) at 24~~0~~ degrees C (75 degrees F).
- B. Pipe insulation for use at temperatures up to 200 degrees C (400 degrees F) with all service vapor retarder jacket.

2.5 POLYISOCYANURATE CLOSED-CELL RIGID (NOT USED)

2.6 FLEXIBLE ELASTOMERIC CELLULAR THERMAL

ASTM C177, C518, k = 0.039 (0.27) at 24 degrees C (75 degrees F), flame spread not over 25, smoke developed not over 50, for temperatures from minus 4 degrees C (40 degrees F) to 93 degrees C (200 degrees F). No jacket required.

2.7 DUCT WRAP FOR KITCHEN HOOD GREASE DUCTS (NOT USED)

2.8 CALCIUM SILICATE

- A. Preformed pipe Insulation: ASTM C533, Type I and Type II with indicator denoting asbestos-free material. Water proof for exterior installation.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
Bancroft Architects + Engineers

02-01-20

- B. Premolded Pipe Fitting Insulation: ASTM C533, Type I and Type II with indicator denoting asbestos-free material. Water proof for exterior installation.
- C. Equipment Insulation: ASTM C533, Type I and Type II
- D. Characteristics:

Insulation Characteristics		
ITEMS	TYPE I	TYPE II
Temperature, maximum degrees C (degrees F)	649 (1200)	927 (1700)
Density (dry), Kg/m ³ (lb/ ft ³)	232 (14.5)	288 (18)
Thermal conductivity: Min W/ m K (Btu in/h ft ² degrees F)@ mean temperature of 93 degrees C (200 degrees F)	0.059 (0.41)	0.078 (0.540)
Surface burning characteristics: Flame spread Index, Maximum	0	0
Smoke Density index, Maximum	0	0

2.9 INSULATION FACINGS AND JACKETS

- A. Vapor Retarder, higher strength with low water permeance = 0.02 or less perm rating, Beach puncture 50 units for insulation facing on exposed ductwork, casings and equipment, and for pipe insulation jackets. Facings and jackets shall be all service type (ASJ) or PVDC Vapor Retarder jacketing.
- B. ASJ jacket shall be white kraft bonded to 0.025 mm (1 mil) thick aluminum foil, fiberglass reinforced, with pressure sensitive adhesive closure. Comply with ASTM C1136. Beach puncture 50 units, Suitable for painting without sizing. Jackets shall have minimum 40 mm (1-1/2 inch) lap on longitudinal joints and minimum 75 mm (3 inch) butt strip on end joints. Butt strip material shall be same as the jacket. Lap and butt strips shall be self-sealing type with factory-applied pressure sensitive adhesive.
- C. Vapor Retarder medium strength with low water vapor permeance of 0.02 or less perm rating), Beach puncture 25 units: Foil-Scrim-Kraft (FSK)

02-01-20

or PVDC vapor retarder jacketing type for concealed ductwork and equipment.

- D. Field applied vapor barrier jackets shall be provided, in addition to the specified facings and jackets, on all exterior piping and ductwork as well as on interior piping and ductwork. The vapor barrier jacket shall consist of a multi-layer laminated cladding with a maximum water vapor permeance of 0.001 perms. The minimum puncture resistance shall be 35 cm-kg (30 inch-pounds) for interior locations and 92 cm-kg (80 inch-pounds) for exterior or exposed locations or where the insulation is subject to damage.
- E. Glass Cloth Jackets: Presized, minimum 0.18 kg per square meter (7.8 ounces per square yard), 2000 kPa (300 psig) bursting strength with integral vapor retarder where required or specified. Weather proof if utilized for outside service.
- F. Factory composite materials may be used provided that they have been tested and certified by the manufacturer.
- G. Pipe fitting insulation covering (jackets): Fitting covering shall be premolded to match shape of fitting and shall be polyvinyl chloride (PVC) conforming to Fed Spec L-P-335, composition A, Type II Grade GU, and Type III, minimum thickness 0.7 mm (0.03 inches). Provide color matching vapor retarder pressure sensitive tape.
- H. Aluminum Jacket-Piping systems: ASTM B209, 3003 alloy, H-14 temper, 0.6 mm (0.023 inch) minimum thickness with locking longitudinal joints. Jackets for elbows, tees and other fittings shall be factory-fabricated to match shape of fitting and of 0.6 mm (0.024) inch minimum thickness aluminum. Fittings shall be of same construction as straight run jackets but need not be of the same alloy. Factory-fabricated stainless steel bands shall be installed on all circumferential joints. Bands shall be 13 mm (0.5 inch) wide on 450 mm (18 inch) centers. System shall be weatherproof if utilized for outside service.

2.10 REMOVABLE INSULATION JACKETS

- A. Insulation and Jacket:
 - 1. Non-Asbestos Glass mat, type E needled fiber.
 - 2. Temperature maximum of 450°F, Maximum water vapor transmission of 0.00 perm, and maximum moisture absorption of 0.2 percent by volume.
 - 3. Jacket Material: Silicon/fiberglass and LFP 2109 pure PTFE.

02-01-20

4. Construction: One piece jacket body with three-ply braided pure Teflon or Kevlar thread and insulation sewn as part of jacket. Belt fastened.

2.11 PIPE COVERING PROTECTION SADDLES

- A. Cold pipe support: Premolded pipe insulation 180 degrees (half-shells) on bottom half of pipe at supports. Material shall be cellular glass or high density Polyisocyanurate insulation of the same thickness as adjacent insulation. Density of Polyisocyanurate insulation shall be a minimum of 48 kg/m³ (3.0 pcf).

Nominal Pipe Size and Accessories Material (Insert Blocks)	
Nominal Pipe Size mm (inches)	Insert Blocks mm (inches)
Up through 125 (5)	150 (6) long
150 (6)	150 (6) long
200 (8), 250 (10), 300 (12)	225 (9) long
350 (14), 400 (16)	300 (12) long
450 through 600 (18 through 24)	350 (14) long

- B. Warm or hot pipe supports: Premolded pipe insulation (180 degree half-shells) on bottom half of pipe at supports. Material shall be high density Polyisocyanurate (for temperatures up to 149 degrees C [300 degrees F]), cellular glass or calcium silicate. Insulation at supports shall have same thickness as adjacent insulation. Density of Polyisocyanurate insulation shall be a minimum of 48 kg/m³ (3.0 pcf).

2.12 ADHESIVE, MASTIC, CEMENT

- A. Mil. Spec. MIL-A-3316, Class 1: Jacket and lap adhesive and protective finish coating for insulation.
- B. Mil. Spec. MIL-A-3316, Class 2: Adhesive for laps and for adhering insulation to metal surfaces.
- C. Mil. Spec. MIL-A-24179, Type II Class 1: Adhesive for installing flexible unicellular insulation and for laps and general use.
- D. Mil. Spec. MIL-C-19565, Type I: Protective finish for outdoor use.
- E. Mil. Spec. MIL-C-19565, Type I or Type II: Vapor barrier compound for indoor use.
- F. ASTM C449: Mineral fiber hydraulic-setting thermal insulating and finishing cement.

G. Other: Insulation manufacturers' published recommendations.

2.13 MECHANICAL FASTENERS

- A. Pins, anchors: Welded pins, or metal or nylon anchors with galvanized steel-coated or fiber washer, or clips. Pin diameter shall be as recommended by the insulation manufacturer.
- B. Staples: Outward clinching monel or galvanized steel.
- C. Wire: 1.3 mm thick (18 gage) soft annealed galvanized or 1.9 mm (14 gage) copper clad steel or nickel copper alloy.
- D. Bands: 13 mm (0.5 inch) nominal width, brass, galvanized steel, aluminum or stainless steel.

2.14 REINFORCEMENT AND FINISHES

- A. Glass fabric, open weave: ASTM D1668, Type III (resin treated) and Type I (asphalt treated).
- B. Glass fiber fitting tape: Mil. Spec MIL-C-20079, Type II, Class 1.
- C. Tape for Flexible Elastomeric Cellular Insulation: As recommended by the insulation manufacturer.
- D. Hexagonal wire netting: 25 mm (one inch) mesh, 0.85 mm thick (22 gage) galvanized steel.
- E. Corner beads: 50 mm (2 inch) by 50 mm (2 inch), 0.55 mm thick (26 gage) galvanized steel; or, 25 mm (1 inch) by 25 mm (1 inch), 0.47 mm thick (28 gage) aluminum angle adhered to 50 mm (2 inch) by 50 mm (2 inch) Kraft paper.
- F. PVC fitting cover: Fed. Spec L-P-535, Composition A, 11-86 Type II, Grade GU, with Form B Mineral Fiber insert, for media temperature 4 degrees C (40 degrees F) to 121 degrees C (250 degrees F). Below 4 degrees C (40 degrees F) and above 121 degrees C (250 degrees F). Provide double layer insert. Provide color matching vapor barrier pressure sensitive tape.

2.15 FIRESTOPPING MATERIAL

- A. Other than pipe and duct insulation, refer to Section 07 84 00 FIRESTOPPING.

2.16 FLAME AND SMOKE

- A. Unless shown otherwise all assembled systems shall meet flame spread 25 and smoke developed 50 rating as developed under ASTM, NFPA and UL standards and specifications. See paragraph 1.3 "Quality Assurance".

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

- A. Required pressure tests of duct and piping joints and connections shall be completed and the work approved by the Resident Engineer for application of insulation. Surface shall be clean and dry with all foreign materials, such as dirt, oil, loose scale and rust removed.
- B. Except for specific exceptions, insulate entire specified equipment, piping (pipe, fittings, valves, accessories), and duct systems. Insulate each pipe and duct individually. Do not use scrap pieces of insulation where a full length section will fit.
- C. Where removal of insulation of piping, ductwork and equipment is required to comply with Section 02 82 11, TRADITIONAL ASBESTOS ABATEMENT and Section 02 82 13.13, GLOVEBAG ASBESTOS ABATEMENT, such areas shall be reinsulated to comply with this specification.
- D. Insulation materials shall be installed in a first class manner with smooth and even surfaces, with jackets and facings drawn tight and smoothly cemented down at all laps. Insulation shall be continuous through all sleeves and openings, except at fire dampers and duct heaters (NFPA 90A). Vapor retarders shall be continuous and uninterrupted throughout systems with operating temperature 16 degrees C (60 degrees F) and below. Lap and seal vapor retarder over ends and exposed edges of insulation. Anchors, supports and other metal projections through insulation on cold surfaces shall be insulated and vapor sealed for a minimum length of 150 mm (6 inches).
- E. Install vapor stops at all insulation terminations on either side of valves, pumps and equipment and particularly in straight lengths of pipe insulation.
- F. Protect all insulations outside of buildings with aluminum jacket using lock joint or other approved system for a continuous weather tight system. Access doors and other items requiring maintenance or access shall be removable and sealable.
- G. HVAC work not to be insulated:
 - 1. Internally insulated ductwork and air handling units.
 - 2. Relief air ducts (Economizer cycle exhaust air).
 - 3. Exhaust air ducts and plenums, and ventilation exhaust air shafts.

- H. Apply insulation materials subject to the manufacturer's recommended temperature limits. Apply adhesives, mastic and coatings at the manufacturer's recommended minimum coverage.
- I. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straights. The elbow/ fitting insulation shall be field-fabricated, mitered or factory prefabricated to the necessary size and shape to fit on the elbow/ fitting. Use of polyurethane spray-foam to fill a PVC elbow jacket is prohibited on cold applications.
- J. Firestop Pipe and Duct insulation:
1. Provide firestopping insulation at fire and smoke barriers through penetrations. Fire stopping insulation shall be UL listed as defines in Section 07 84 00, FIRESTOPPING.
 2. Pipe and duct penetrations requiring firestop insulation including, but not limited to the following:
 - a. Pipe risers through floors
 - b. Pipe or duct chase walls and floors
 - c. Smoke partitions
 - d. Fire partitions
- K. Provide vapor barrier jackets over insulation as follows:
1. All ductwork exposed to outdoor weather.
- L. Provide metal jackets over insulation as follows:
1. All ducts exposed to outdoor weather.
 2. A 50 mm (2 inch) overlap is required at longitudinal and circumferential joints.

3.2 INSULATION INSTALLATION

- A. Mineral Fiber Board:
1. Faced board: Apply board on pins spaced not more than 300 mm (12 inches) on center each way, and not less than 75 mm (3 inches) from each edge of board. In addition to pins, apply insulation bonding adhesive to entire underside of horizontal metal surfaces. Butt insulation edges tightly and seal all joints with laps and butt strips. After applying speed clips cut pins off flush and apply vapor seal patches over clips.
 2. Plain board:

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
Bancroft Architects + Engineers

02-01-20

- a. Insulation shall be scored, beveled or mitered to provide tight joints and be secured to equipment with bands spaced 225 mm (9 inches) on center for irregular surfaces or with pins and clips on flat surfaces. Use corner beads to protect edges of insulation.
- b. For cold equipment: Apply meshed glass fabric in a tack coat 1.5 to 1.7 square meter per liter (60 to 70 square feet per gallon) of vapor mastic and finish with mastic at 0.3 to 0.4 square meter per liter (12 to 15 square feet per gallon) over the entire fabric surface.
3. Exposed, unlined ductwork and equipment in unfinished areas, mechanical and electrical equipment rooms and attics, interstitial spaces and duct work exposed to outdoor weather:
 - a. 40 mm (1-1/2 inch) thick insulation faced with ASJ (white all service jacket): Supply air duct unlined air handling units and after filter housing.
 - b. 40 mm (1-1/2 inch) thick insulation faced with ASJ: Return air duct, mixed air plenums and prefilter housing.
 - c. Outside air intake ducts: no insulation required 25 mm (one inch) thick insulation faced with ASJ.
 - d. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a reinforcing membrane and two coats of vapor barrier mastic or multi-layer vapor barrier with a maximum water vapor permeability of 0.001 perms.
4. Supply air duct in the warehouse and in the laundry: 25 mm (one inch) thick insulation faced with ASJ.
5. Cold equipment: 40 mm (1-1/2 inch) thick insulation faced with ASJ.
 - a. Chilled water pumps, water filter, chemical feeder pot or tank.
 - b. Pneumatic, cold storage water and surge tanks.
- B. Flexible Mineral Fiber Blanket:
 1. Adhere insulation to metal with 75 mm (3 inch) wide strips of insulation bonding adhesive at 200 mm (8 inches) on center all around duct. Additionally secure insulation to bottom of ducts exceeding 600 mm (24 inches) in width with pins welded or adhered on 450 mm (18 inch) centers. Secure washers on pins. Butt insulation

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
Bancroft Architects + Engineers

02-01-20

- edges and seal joints with laps and butt strips. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations with mastic. Sagging duct insulation will not be acceptable. Install firestop duct insulation where required.
2. Supply air ductwork to be insulated includes main and branch ducts from AHU discharge to room supply outlets, and the bodies of ceiling outlets to prevent condensation. Insulate sound attenuator units, coil casings and damper frames. To prevent condensation insulate trapeze type supports and angle iron hangers for flat oval ducts that are in direct contact with metal duct.
 3. Concealed supply air ductwork.
 - a. Above ceilings at a roof level, in attics, and duct work exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with FSK.
 - b. Above ceilings for other than roof level: 40 mm (1 ½ inch) thick insulation faced with FSK.
 4. Concealed return air duct:
 - a. In attics (where not subject to damage) and where exposed to outdoor weather: 50mm (2 inch) thick insulation faced with FSK.
 - b. Above ceilings at a roof level, unconditioned areas, and in chases with external wall or containing steam piping; 40 mm (1-1/2 inch) thick, insulation faced with FSK.
 - c. In interstitial spaces (where not subject to damage): 40 mm (1-1/2 inch) thick insulation faced with FSK.
 - d. Concealed return air ductwork in other locations need not be insulated.
 5. Concealed outside air duct: 40 mm (1-1/2 inch) thick insulation faced with FSK.
- C. Molded Mineral Fiber Pipe and Tubing Covering:
1. Fit insulation to pipe or duct, aligning longitudinal joints. Seal longitudinal joint laps and circumferential butt strips by rubbing hard with a nylon sealing tool to assure a positive seal. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations on cold piping with a generous application of vapor barrier mastic. Provide inserts and install with metal

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
Bancroft Architects + Engineers

02-01-20

insulation shields at outside pipe supports. Install freeze protection insulation over heating cable.

2. Contractor's options for fitting, flange and valve insulation:
 - a. Insulating and finishing cement for sizes less than 100 mm (4 inches) operating at surface temperature of 16 degrees C (61 degrees F) or more.
 - b. Factory premolded, one piece PVC covers with mineral fiber, (Form B), inserts. Provide two insert layers for pipe temperatures below 4 degrees C (40 degrees F), or above 121 degrees C (250 degrees F). Secure first layer of insulation with twine. Seal seam edges with vapor barrier mastic and secure with fitting tape.
 - c. Factory molded, ASTM C547 or field mitered sections, joined with adhesive or wired in place. For hot piping finish with a smoothing coat of finishing cement. For cold fittings, 16 degrees C (60 degrees F) or less, vapor seal with a layer of glass fitting tape imbedded between two 2 mm (1/16 inch) coats of vapor barrier mastic.
 - d. Fitting tape shall extend over the adjacent pipe insulation and overlap on itself at least 50 mm (2 inches).
3. Nominal thickness in millimeters and inches specified in the schedule at the end of this section.

D. Rigid Cellular Phenolic Foam:

1. Rigid closed cell phenolic insulation may be provided for piping, ductwork and equipment for temperatures up to 121 degrees C (250 degrees F).
2. Note the NFPA 90A burning characteristics requirements of 25/50 in paragraph 1.3.B
3. Provide secure attachment facilities such as welding pins.
4. Apply insulation with joints tightly drawn together
5. Apply adhesives, coverings, neatly finished at fittings, and valves.
6. Final installation shall be smooth, tight, neatly finished at all edges.
7. Minimum thickness in millimeters (inches) specified in the schedule at the end of this section.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
Bancroft Architects + Engineers

02-01-20

8. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a multi-layer vapor barrier with a maximum water vapor permeance of 0.00 perms.
9. Condensation control insulation: Minimum 25 mm (1.0 inch) thick for all pipe sizes.
 - a. HVAC: Cooling coil condensation piping to waste piping fixture or drain inlet. Omit insulation on plastic piping in mechanical rooms.

E. Cellular Glass Insulation:

1. Pipe and tubing, covering nominal thickness in millimeters and inches as specified in the schedule at the end of this section.
2. Underground Piping Other than or in lieu of that Specified in Section 23 21 13, HYDRONIC PIPING and Section 33 63 00, STEAM ENERGY DISTRIBUTION: Type II, factory jacketed with a 3 mm laminate jacketing consisting of 3000 mm x 3000 mm (10 ft x 10 ft) asphalt impregnated glass fabric, bituminous mastic and outside protective plastic film.
 - a. 75 mm (3 inches) thick for hot water piping.
 - b. As scheduled at the end of this section for chilled water piping.
 - c. Underground piping: Apply insulation with joints tightly butted. Seal longitudinal self-sealing lap. Use field fabricated or factory made fittings. Seal butt joints and fitting with jacketing as recommended by the insulation manufacturer. Use 100 mm (4 inch) wide strips to seal butt joints.
 - d. Provide expansion chambers for pipe loops, anchors and wall penetrations as recommended by the insulation manufacturer.
 - e. Underground insulation shall be inspected and approved by the Resident Engineer as follows:
 - 1) Insulation in place before coating.
 - 2) After coating.
 - f. Sand bed and backfill: Minimum 75 mm (3 inches) all around insulated pipe or tank, applied after coating has dried.
3. Cold equipment: 50 mm (2 inch) thick insulation faced with ASJ for chilled water pumps, water filters, chemical feeder pots or tanks, expansion tanks, air separators and air purgers.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
Bancroft Architects + Engineers

02-01-20

4. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a reinforcing membrane and two coats of vapor barrier mastic or multi-layer vapor barrier with a water vapor permeability of 0.00 perms.

F. Polyisocyanurate Closed-Cell Rigid Insulation:

1. Polyisocyanurate closed-cell rigid insulation (PIR) may be provided for exterior piping, equipment and ductwork for temperature up to 149 degree C (300 degree F).
2. Install insulation, vapor barrier and jacketing per manufacturer's recommendations. Particular attention should be paid to recommendations for joint staggering, adhesive application, external hanger design, expansion/contraction joint design and spacing and vapor barrier integrity.
3. Install insulation with all joints tightly butted (except expansion joints in hot applications).
4. If insulation thickness exceeds 63 mm (2.5 inches), install as a double layer system with longitudinal (lap) and butt joint staggering as recommended by manufacturer.
5. For cold applications, vapor barrier shall be installed in a continuous manner. No staples, rivets, screws or any other attachment device capable of penetrating the vapor barrier shall be used to attach the vapor barrier or jacketing. No wire ties capable of penetrating the vapor barrier shall be used to hold the insulation in place. Banding shall be used to attach PVC or metal jacketing.
6. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straights. The elbow/ fitting insulation shall be field-fabricated, mitered or factory prefabricated to the necessary size and shape to fit on the elbow/ fitting. Use of polyurethane spray-foam to fill PVC elbow jacket is prohibited on cold applications.
7. For cold applications, the vapor barrier on elbows/fittings shall be either mastic-fabric-mastic or 2 mil thick PVDC vapor barrier adhesive tape.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
Bancroft Architects + Engineers

02-01-20

8. All PVC and metal jacketing shall be installed so as to naturally shed water. Joints shall point down and shall be sealed with either adhesive or caulking (except for periodic slip joints).
 9. Underground piping: Follow instructions for above ground piping but the vapor retarder jacketing shall be 6 mil thick PVDC or minimum 30 mil thick rubberized bituminous membrane. Sand bed and backfill shall be a minimum of 150 mm (6 inches) all around insulated pipe.
 10. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a multi-layer vapor barrier with a water vapor permeance of 0.00 perms.
 11. Note the NFPA 90A burning characteristic requirements of 25/50 in paragraph 1.3B. Refer to paragraph 3.1 for items not to be insulated.
 12. Minimum thickness in millimeter (inches) specified in the schedule at the end of this section.
- G. Flexible Elastomeric Cellular Thermal Insulation:
1. Apply insulation and fabricate fittings in accordance with the manufacturer's installation instructions and finish with two coats of weather resistant finish as recommended by the insulation manufacturer.
 2. Pipe and tubing insulation:
 - a. Use proper size material. Do not stretch or strain insulation.
 - b. To avoid undue compression of insulation, provide cork stoppers or wood inserts at supports as recommended by the insulation manufacturer. Insulation shields are specified under Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
 - c. Where possible, slip insulation over the pipe or tubing prior to connection, and seal the butt joints with adhesive. Where the slip-on technique is not possible, slit the insulation and apply it to the pipe sealing the seam and joints with contact adhesive. Optional tape sealing, as recommended by the manufacturer, may be employed. Make changes from mineral fiber insulation in a straight run of pipe, not at a fitting. Seal joint with tape.
 3. Apply sheet insulation to flat or large curved surfaces with 100 percent adhesive coverage. For fittings and large pipe, apply adhesive to seams only.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
Bancroft Architects + Engineers

02-01-20

4. Pipe insulation: nominal thickness in millimeters (inches as specified in the schedule at the end of this section.
5. Minimum 20 mm (0.75 inch) thick insulation for pneumatic control lines for a minimum distance of 6 m (20 feet) from discharge side of the refrigerated dryer.
refrigerators and freezers: Provide heat tape under insulation.
6. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a multi-layer vapor barrier with a water vapor permeance of 0.00 perms.

H. Calcium Silicate:

1. Minimum thickness in millimeter (inches) specified in the schedule at the end of this section for piping other than in boiler plant. See paragraphs 3.3 through 3.7 for Boiler Plant Applications.
2. Engine Exhaust Insulation for Emergency Generator and Diesel Driven Fire Pump: Type II, Class D, 65 mm (2 1/2 inch) nominal thickness. Cover exhaust completely from engine through roof or wall construction, including muffler. Secure with 16 AWG galvanized annealed wire or 0.38 x 12 mm 0.015 x 1/2 IN wide galvanized bands on 300 mm 12 IN maximum centers. Anchor wire and bands to welded pins, clips or angles. Apply 25 mm 1 IN hex galvanized wire over insulation. Fill voids with 6 mm 1/4 IN insulating cement.
3. ETO Exhaust (High Temperature): Type II, class D, 65 mm (2.5 inches) nominal thickness. Cover duct for entire length. Provide sheet aluminum jacket for all exterior ductwork.

3.3 APPLICATION -BOILER PLANT, PIPE, VALVES, STRAINERS AND FITTINGS: (NOT USED)

3.4 APPLICATION-BOILER FLUE GAS SYSTEMS (NOT USED)

3.5 APPLICATION-BOILER DEAERATING FEEDWATER HEATER, TANKS (NOT USED)

3.6 APPLICATION ON HEATED OR TRACED OIL FACILITIES OUTSIDE OF BUILDING (NOT USED)

3.7 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to section 23 08 00 -

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
 Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
 Bancroft Architects + Engineers

02-01-20

COMMISSIONING OF HVAC SYSTEMS and related sections for contractor
 responsibilities for system commissioning.

3.8 PIPE INSULATION SCHEDULE

Provide insulation for piping systems as scheduled below:

Insulation Wall Thickness Millimeters (Inches)					
		Nominal Pipe Size Millimeters (Inches)			
Operating Temperature Range/Service	Insulation Material	Less than 25 (1)	25 - 32 (1 - 1¼)	38 - 75 (1½ - 3)	100 (4) and Above
Insulation Wall Thickness Millimeters (Inches)					
100-121 degrees C (212-250 degrees F) (vent piping from PRV Safety Valves, Condensate receivers and flash tanks)	Mineral Fiber (Above ground piping only)	62 (2.5)	62 (2.5)	75 (3.0)	75 (3.0)
100-121 degrees C (212-250 degrees F) (vent piping from PRV Safety Valves, Condensate receivers and flash tanks)	Rigid Cellular Phenolic Foam	50 (2.0)	50 (2.0)	75 (3.0)	75 (3.0)
38-94 degrees C (100-200 degrees F) (HWH, HWHR, GH and GHR)	Mineral Fiber (Above ground piping only)	38 (1.5)	38 (1.5)	50 (2.0)	50 (2.0)
38-99 degrees C (100-211 degrees F) (PC, HWH, HWHR, GH and GHR)	Rigid Cellular Phenolic Foam	38 (1.5)	38 (1.5)	50 (2.0)	50 (2.0)
39-99 degrees C (100-211 degrees F) (PC, HWH, HWHR, GH and GHR)	Polyiso-cyanurate Closed-Cell Rigid (Exterior Locations only)	38 (1.5)	38 (1.5)	----	----
38-94 degrees C (100-200 degrees F) (PC, HWH, HWHR, GH and GHR)	Flexible Elastomeric Cellular Thermal (Above ground piping only)	38 (1.5)	38 (1.5)	----	----

Contract No. 36C26319D0044
 Station Project No. 437-21-210
 Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
 Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
 Bancroft Architects + Engineers

02-01-20

4-16 degrees C (40-60 degrees F) (CH, CHR, GC, GCR and RS for DX refrigeration)	Rigid Cellular Phenolic Foam	38 (1.5)	38 (1.5)	38 (1.5)	38 (1.5)
4-16 degrees C (40-60 degrees F) (CH and CHR within chiller room and pipe chase and underground)	Cellular Glass Closed- Cell	50 (2.0)	50 (2.0)	75 (3.0)	75 (3.0)
4-16 degrees C (40-60 degrees F) (CH, CHR, GC, GCR and RS for DX refrigeration)	Cellular Glass Closed- Cell	38 (1.5)	38 (1.5)	38 (1.5)	38 (1.5)
4-16 degrees C (40-60 degrees F) (CH, CHR, GC and GCR (where underground)	Polyiso- cyanurate Closed-Cell Rigid	38 (1.5)	38 (1.5)	50 (2.0)	50 (2.0)
4-16 degrees C (40-60 degrees F) (CH, CHR, GC, GCR and RS for DX refrigeration)	Polyiso- cyanurate Closed-Cell Rigid (Exterior Locations only)	38 (1.5)	38 (1.5)	38 (1.5)	38 (1.5)
(40-60 degrees F) (CH, CHR, GC, GCR and RS for DX refrigeration)	Flexible Elastomeric Cellular Thermal (Above ground piping only)	38 (1.5)	38 (1.5)	38 (1.5)	38 (1.5)

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Contract No. 36C26319D0044
 Station Project No. 437-21-210
 Bancroft-AE Project No. 22-113

01/16/2024

SECTION 23 08 00
COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The requirements of this Section apply to all sections of Division 23.
- B. This project will have selected building systems commissioned. The complete list of equipment and systems to be commissioned is specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. The commissioning process, which the Contractor is responsible to execute, is defined in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. A Commissioning Agent (CxA) appointed by the VA will manage the commissioning process.

1.2 RELATED WORK

- A. Section 01 00 00 GENERAL REQUIREMENTS.
- B. Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.
- D. Section 23 05 41 NOISE AND VIBRATION CONTROL for HVAC PIPING AND EQUIPMENT.
- E. Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC.
- F. Section 23 09 23 DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

1.3 SUMMARY

- A. This Section includes requirements for commissioning the HVAC systems of the related subsystems and equipment. This Section supplements the general requirements specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.
- B. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for more details regarding processes and procedures as well as roles and responsibilities for all Commissioning Team members.

1.4 DEFINITIONS

- A. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for definitions.

1.5 COMMISSIONED SYSTEMS

- A. Commissioning of a system or systems specified in Division 23 is part of the construction process. Documentation and testing of these systems, as well as training of the VA's Operation and Maintenance personnel in accordance with the requirements of Section 01 91 00

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

GENERAL COMMISSIONING REQUIREMENTS and of Division 23, is required in cooperation with the VA and the Commissioning Agent.

- B. The Facility HVAC systems commissioning will include the systems listed in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

1.6 SUBMITTALS

- A. The commissioning process requires review of selected Submittals that pertain to the systems to be commissioned. The Commissioning Agent will provide a list of submittals that will be reviewed by the Commissioning Agent. This list will be reviewed and approved by the VA prior to forwarding to the Contractor. Refer to Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, and SAMPLES for further details.
- B. The commissioning process requires Submittal review simultaneously with engineering review. Specific submittal requirements related to the commissioning process are specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

1.7 APPLICABLE PUBLICATIONS

- A. The following publications form a part of this specification to the extent indicated by the reference thereto. In text the publications are referenced to by the acronym of the organization.
- B. Department of Veterans Affairs (VA):
PG 18-10 2007.....Mission Critical Facilities - DRAFT
PG 18-10 2007.....Life-Safety Protected Facilities - DRAFT
- C. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE):
HANDBOOK 2019.....HVAC Applications ASHRAE Handbook, Chapter 39,
Testing, Adjusting, and Balancing, Chapter 44,
HVAC Commissioning and Chapter 49, Sound and
Vibration Control
HANDBOOK 2017.....HVAC Fundamentals ASHRAE Handbook, Chapter 8,
Sound and Vibration
- D. Associated Air Balance Council (AABC):
7th Edition 2016.....AABC National Standards for Total System
Balance
- E. National Environmental Balancing Bureau (NEBB):
9th Edition 2019.....Procedural Standards for Testing, Adjusting,
Balancing of Environmental Systems

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

3rd Edition 2015.....Procedural Standards for the Measurement of
Sound and Vibration

2nd Edition 2019... Standard for Whole Building Technical Commissioning
of New Construction

F. Sheet Metal and Air Conditioning Contractors National Association
(SMACNA):

006 2006.....HVAC Duct Construction Standard - Metal and
Flexible Duct

3rd Edition 2005 ... HVAC Systems Testing, Adjusting and Balancing

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CONSTRUCTION INSPECTIONS

A. Commissioning of HVAC systems will require inspection of individual elements of the HVAC systems construction throughout the construction period. The Contractor shall coordinate with the Commissioning Agent in accordance with Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS and the Commissioning plan to schedule HVAC systems inspections as required to support the Commissioning Process.

3.2 PRE-FUNCTIONAL CHECKLISTS

A. The Contractor shall complete Pre-Functional Checklists to verify systems, subsystems, and equipment installation is complete and systems are ready for Systems Functional Performance Testing. The Commissioning Agent will prepare Pre-Functional Checklists to be used to document equipment installation. Refer to Sections 23 05 41 NOISE AND VIBRATION CONTROL for HVAC PIPING AND EQUIPMENT, Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and Section 23 09 23 DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC requirements. The Contractor shall complete the checklists. Completed checklists shall be submitted to the VA and to the Commissioning Agent for review. The Commissioning Agent may spot check a sample of completed checklists. If the Commissioning Agent determines that the information provided on the checklist is not accurate, the Commissioning Agent will return the marked-up checklist to the Contractor for correction and resubmission. If the Commissioning Agent determines that a significant number of completed checklists for similar equipment are not accurate, the Commissioning Agent will select a broader sample of checklists for

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

review. If the Commissioning Agent determines that a significant number of the broader sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and resubmission. Refer to SECTION 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for submittal requirements for Pre-Functional Checklists, Equipment Startup Reports, and other commissioning documents.

3.3 CONTRACTORS TESTS

- A. Contractor tests as required by other sections of Division 23 shall be scheduled and documented in accordance with Section 01 00 00 GENERAL REQUIREMENTS. All testing shall be incorporated into the project schedule. Contractor shall provide no less than 7 calendar days' notice of testing. The Commissioning Agent will witness selected Contractor tests at the sole discretion of the Commissioning Agent. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.4 SYSTEMS FUNCTIONAL PERFORMANCE TESTING:

- A. The Commissioning Process includes Systems Functional Performance Testing that is intended to test systems functional performance under steady state conditions, to test system reaction to changes in operating conditions, and system performance under emergency conditions. The Commissioning Agent will prepare detailed Systems Functional Performance Test procedures for review and approval by the Resident Engineer. The Contractor shall review and comment on the tests prior to approval. The Contractor shall provide the required labor, materials, and test equipment identified in the test procedure to perform the tests. The Commissioning Agent will witness and document the testing. The Contractor shall sign the test reports to verify tests were performed. See Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS, for additional requirements.

3.5 TRAINING OF VA PERSONNEL

- A. Training of the VA operation and maintenance personnel is required in cooperation with the Resident Engineer and Commissioning Agent. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. Contractor

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

shall submit training agendas and trainer resumes in accordance with the requirements of Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. The instruction shall be scheduled in coordination with the VA Resident Engineer after submission and approval of formal training plans. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS and Division 23 Sections for additional Contractor training requirements.

----- **END** -----

SECTION 23 09 23
DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

A. General Contractor shall provide direct-digital control system(s) as indicated on the project documents, point list, interoperability tables, drawings and as described in these specifications. Include a complete and working direct-digital control system. Include all engineering, programming, configuration/setup hardware and software, controls and installation materials, installation labor, commissioning and startup, training, final project documentation and warranty.

1. The direct-digital control system(s) shall consist of high-speed, peer-to-peer network of DDC controllers, a control system server, all configuration and setup software and hardware devices, and an Engineering Control Center. Provide a remote user using to access the control system graphics and change adjustable setpoints with the proper password.
2. All new building controllers shall be native BACnet. All new BACnet workstations, controllers, devices and components shall be listed by BACnet Testing Laboratories. All new BACnet workstations, controllers, devices and components shall be accessible using a HTML5 Web browser interface. Browsers shall not require the use of an extension or add on software in order to access aforementioned workstations, controllers, devices, and components.
 - a. If used, gateways shall be BTL listed.
 - b. If used, gateways shall provide all object properties and read/write services shown on VA-approved interoperability schedules.
3. The work administered by this Section of the technical specifications shall include all labor, materials, special tools, equipment, enclosures, power supplies, software, software licenses, Project specific software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, submittals, testing, verification, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance,

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- Warranty, specified services and any other items required for a complete and fully functional Controls System.
4. The control systems shall be designed such that each mechanical system shall operate under stand-alone mode. The A/E shall designate what each "mechanical systems" is composed of. The contractor administered by this Section of the technical specifications shall provide controllers for each mechanical system. In the event of a network communication failure, or the loss of any other controller, the control system shall continue to operate independently. Failure of the ECC shall have no effect on the field controllers, including those involved with global strategies.
 5. The control system shall accommodate 1 Engineering Control Center(s) and the control system shall accommodate 5 web-based Users simultaneously, and the access to the system should be limited only by operator password.
- B. Some products are furnished but not installed by the contractor administered by this Section of the technical specifications. The contractor administered by this Section of the technical specifications shall formally coordinate in writing and receive from other contractors formal acknowledgements in writing prior to submission the installation of the products. These products include but are not limited to the following:
1. Control valves.
 2. Flow switches.
 3. Flow meters.
 4. Sensor wells and sockets in piping.
- C. Some products are installed but not furnished by the contractor administered by this Section of the technical specifications. The contractor administered by this Section of the technical specifications shall formally coordinate in writing and receive from other contractors formal acknowledgements in writing prior to submission the procurement of the products. These products include but are not limited to the following:
1. Factory-furnished accessory thermostats and sensors furnished with unitary equipment.
- D. Some products are not provided by, but are nevertheless integrated with the work executed by, the contractor administered by this Section of the

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

technical specifications. These products include but are not limited to the following:

1. Unitary HVAC equipment (rooftop air conditioning units, split systems, packaged pumping stations) controls. These include:
 - a. Discharge temperature control.
 - b. Flowrate control.
 - c. Setpoint reset.
 - d. Time of day indexing.
 - e. Status alarm.
2. Variable frequency drives. These controls, if not native BACnet, will require a BACnet Gateway.
3. The following systems have limited control (as individually noted below) from the ECC:
 - a. Emergency generators: status alarms.

E.

Work/Item/System	Furnish	Install	Low Voltage Wiring	Line Power
Control system low voltage and communication wiring	23 09 23	23 09 23	23 09 23	N/A
Automatic dampers (not furnished with equipment)	23 09 23	23	N/A	N/A
Automatic damper actuators	23 09 23	23 09 23	23 09 23	23 09 23
Manual valves	23	23	N/A	N/A
Automatic valves	23 09 23	23	23 09 23	23 09 23
Pipe insertion devices and taps, flow and pressure stations.	23	23	N/A	N/A
Thermowells	23 09 23	23	N/A	N/A
Current Switches	23 09 23	23 09 23	23 09 23	N/A
Control Relays	23 09 23	23 09 23	23 09 23	N/A
All control system nodes, equipment, housings, enclosures and panels.	23 09 23	23 09 23	23 09 23	26
VFDs	23	26	23 09 23	26
Computer Room A/C Unit field-mounted controls	23	23	26	26

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

Work/Item/System	Furnish	Install	Low Voltage Wiring	Line Power
Control system interface with CRU A/C controls	23 09 23	23 09 23	23 09 23	26
CRU A/C unit controls interface with control system	23	23 09 23	23 09 23	26
Unit Heater controls (not furnished with equipment)	23 09 23	23 09 23	23 09 23	26

F. This facility's existing direct-digital control (DDC) system is manufactured by Johnson Control. The contractor administered by this Section of the technical specifications shall observe the capabilities, communication network, services, spare capacity of the existing control system and its ECC prior to beginning work.

1. Provide a new BACnet ECC, communications network, and controllers.

Provide a programmable internetworking gateway allowing for real-time communication between the existing direct-digital control system and the new BACnet control system. Real-time communication shall provide all object properties and read/write services shown on VA-approved interoperability schedules. The contractor administered by this Section of the technical specifications shall provide all necessary investigation and site-specific programming to execute the interoperability schedules.

a. The combined system shall operate and function as one complete system including one database of control point objects and global control logic capabilities. Facility operators shall have complete operations and control capability over all systems, new and existing including; monitoring, trending, graphing, scheduling, alarm management, global point sharing, global strategy deployment, graphical operations interface and custom reporting as specified.

b. The combined system shall operate and function as one complete system including one database of control point objects and global control logic capabilities. Facility operators shall have limited operations and control capability over the legacy systems, as described in the VA-approved interoperability schedules.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

2. Upgrade the existing direct-digital control system's ECC to include all properties and services required by an ASHRAE Standard 135 BACnet B-AWS Profile. The upgraded ECC shall continue to communicate with the existing direct-digital control system's devices. The upgraded ECC shall communicate directly with the new native-BACnet devices over the existing control system's communications network without the use of a gateway. Provide programming converting the existing non-BACnet devices, objects and services to ASHRAE Standard 135 BACnet-complaint BIBBs. The contractor administered by this Section of the technical specifications shall provide all necessary investigation and site-specific programming to execute the interoperability schedules.

a. The performance requirement for the combined system: the combined system shall operate and function as one complete system including one database of control point objects and global control logic capabilities. Facility operators shall have complete operations and control capability over all systems, new and existing including; monitoring, trending, graphing, scheduling, alarm management, global point sharing, global strategy deployment, graphical operations interface and custom reporting as specified.

b. The combined system shall operate and function as one complete system including one database of control point objects and global control logic capabilities. Facility operators shall have limited operations and control capability over the legacy systems as described in the VA-approved interoperability schedule.

G. This campus has standardized on an existing standard ASHRAE Standard 135, BACnet/IP Control System supported by a preselected controls service company. This entity is referred to as the "Control System Integrator" in this Section of the technical specifications. The Control system integrator is responsible for ECC system graphics and expansion. It also prescribes control system-specific commissioning/ verification procedures to the contractor administered by this Section of the technical specification. It lastly provides limited assistance to the contractor administered by this Section of the technical specification in its commissioning/verification work.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

1. The General Contractor of this project shall directly hire the Control System Integrator in a contract separate from the contract procuring the controls contractor administered by this Section of the technical specifications.
2. The contractor administered by this Section of the technical specifications shall coordinate all work with the Control System Integrator. The contractor administered by this Section of the technical specifications shall integrate the ASHRAE Standard 135, BACnet/IP control network(s) with the Control System Integrator's B-AWS through an Ethernet connection provided by either the Control System Integrator or VA.
3. The contractor administered by this Section of the technical specifications shall provide a peer-to-peer networked, stand-alone, distributed control system. This direct digital control (DDC) system at least shall include one portable operator terminal - laptop, one digital display unit, microprocessor-based controllers, instrumentation, end control devices, wiring, piping, software, and related systems. This contractor is responsible for all device mounting and wiring.
4. Responsibility Table:

Item/Task	Section 23 09 23 contractor	Control system integrator	VA
ECC expansion		X	
ECC programming		X	
Devices, controllers, control panels and equipment	X		
Point addressing: all hardware and software points including setpoint, calculated point, data point(analog/ binary), and reset schedule point	X		
Point mapping		X	
Network Programming	X		
ECC Graphics		X	
Controller programming and sequences	X		
Integrity of LAN communications			X
Electrical wiring	X		

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

Operator system training		X	
LAN connections to devices			X
LAN connections to ECC			X
IP addresses			X
Overall system verification (Cx)		X	
Controller and system verification	X		

H. Unitary standalone systems including Unit Heaters, Cabinet Unit Heaters, Fan Coil Units, Base Board Heaters, thermal comfort ventilation fans, and similar units for control of room environment conditions may be equipped with integral controls furnished and installed by the equipment manufacturer or field mounted. Refer to equipment specifications and as indicated in project documents. Application of standalone unitary controls is limited to at least those systems wherein remote monitoring, alarm and startup are not necessary. Examples of such systems include:

1. Light-switch-operated toilet exhaust
2. Vestibule heater
3. Exterior stair heater
4. Attic heating and ventilation
5. Mechanical or electrical room heating and ventilation.

I. The direct-digital control system shall start and stop equipment, move (position) damper actuators and valve actuators, and vary speed of equipment to execute the mission of the control system. Use electricity as the motive force for all damper and valve actuators, unless use of pneumatics as motive force is specifically granted in writing by the VA.

1.2 RELATED WORK

- A. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.
- B. Section 13 21 29, Constant Temperature Rooms.
- C. Section 23 09 11, Instrumentation and Control for Boiler Plant.
- D. Section 23 21 13, Hydronic Piping.
- E. Section 23 31 00, HVAC Ducts and Casings.
- F. Section 23 36 00, Air Terminal Units.
- G. Section 23 81 00, Decentralized Unitary HVAC Equipment.
- H. Section 23 81 23, Computer-Room Air-Conditioners.
- I. Section 26 27 26, Wiring Devices.
- J. Section 26 29 11, Motor Starters.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

K. Section 26 32 13, Engine Generators.

1.3 DEFINITION

- A.Algorithm: A logical procedure for solving a recurrent mathematical problem; A prescribed set of well-defined rules or processes for the solution of a problem in a finite number of steps.
- B.Analog: A continuously varying signal value (e.g., temperature, current, velocity etc.
- C.BACnet: A Data Communication Protocol for Building Automation and Control Networks -as defined by ANSI/ASHRAE Standard 135. This communications protocol allows diverse building automation devices to communicate data and services over a network.
- D.BACnet/IP: Annex J of Standard 135. It defines and allows for using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP sub-networks that share the same BACnet network number.
- E.BACnet Internetwork: Two or more BACnet networks connected with routers. The two networks may use different LAN technologies.
- F.BACnet Network: One or more BACnet segments that have the same network address and are interconnected by bridges at the physical and data link layers.
- G.BACnet Segment: One or more physical segments of BACnet devices on a BACnet network, connected at the physical layer by repeaters.
- H.BACnet Broadcast Management Device (BBMD): A communications device which broadcasts BACnet messages to all BACnet/IP devices and other BBMDs connected to the same BACnet/IP network.
- I.BACnet Interoperability Building Blocks (BIBBs): BACnet Interoperability Building Blocks (BIBBs) are collections of one or more BACnet services. These are prescribed in terms of an "A" and a "B" device. Both of these devices are nodes on a BACnet internetwork.
- J.BACnet Testing Laboratories (BTL). The organization responsible for testing products for compliance with the BACnet standard, operated under the direction of BACnet International.
- K.Baud: It is a signal change in a communication link. One signal change can represent one or more bits of information depending on type of transmission scheme. Simple peripheral communication is normally one

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- bit per Baud. (e.g., Baud rate = 78,000 Baud/sec is 78,000 bits/sec, if one signal change = 1 bit).
- L.Binary: A two-state system where a high signal level represents an "ON" condition and an "OFF" condition is represented by a low signal level.
- M.BMP or bmp: Suffix, computerized image file, used after the period in a DOS-based computer file to show that the file is an image stored as a series of pixels.
- N.Bus Topology: A network topology that physically interconnects workstations and network devices in parallel on a network segment.
- O.Control Unit (CU): Generic term for any controlling unit, stand-alone, microprocessor based, digital controller residing on secondary LAN or Primary LAN, used for local controls or global controls
- P.Deadband: A temperature range over which no heating or cooling is supplied, i.e., 22-25 degrees C (72-78 degrees F), as opposed to a single point change over or overlap).
- Q.Device: a control system component that contains a BACnet Device Object and uses BACnet to communicate with other devices.
- R.Device Object: Every BACnet device requires one Device Object, whose properties represent the network visible properties of that device. Every Device Object requires a unique Object Identifier number on the BACnet internetwork. This number is often referred to as the device instance.
- S.Device Profile: A specific group of services describing BACnet capabilities of a device, as defined in ASHRAE Standard 135, Annex L. Standard device profiles include BACnet Operator Workstations (B-OWS), BACnet Building Controllers (B-BC), BACnet Advanced Application Controllers (B-AAC), BACnet Application Specific Controllers (B-ASC), BACnet Smart Actuator (B-SA), and BACnet Smart Sensor (B-SS). Each device used in new construction is required to have a PICS statement listing which service and BIBBs are supported by the device.
- T.Diagnostic Program: A software test program, which is used to detect and report system or peripheral malfunctions and failures. Generally, this system is performed at the initial startup of the system.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- U. Direct Digital Control (DDC): Microprocessor based control including Analog/Digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices in order to achieve a set of predefined conditions.
- V. Distributed Control System: A system in which the processing of system data is decentralized and control decisions can and are made at the subsystem level. System operational programs and information are provided to the remote subsystems and status is reported back to the Engineering Control Center. Upon the loss of communication with the Engineering Control center, the subsystems shall be capable of operating in a stand-alone mode using the last best available data.
- W. Download: The electronic transfer of programs and data files from a central computer or operation workstation with secondary memory devices to remote computers in a network (distributed) system.
- X. DXF: An AutoCAD 2-D graphics file format. Many CAD systems import and export the DXF format for graphics interchange.
- Y. Electrical Control: A control circuit that operates on line or low voltage and uses a mechanical means, such as a temperature sensitive bimetal or bellows, to perform control functions, such as actuating a switch or positioning a potentiometer.
- Z. Electronic Control: A control circuit that operates on low voltage and uses a solid-state components to amplify input signals and perform control functions, such as operating a relay or providing an output signal to position an actuator.
- AA. Engineering Control Center (ECC): The centralized control point for the intelligent control network. The ECC comprises of personal computer and connected devices to form a single workstation.
- BB. Ethernet: A trademark for a system for exchanging messages between computers on a local area network using coaxial, fiber optic, or twisted-pair cables.
- CC. Firmware: Firmware is software programmed into read only memory (ROM) chips. Software may not be changed without physically altering the chip.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- DD. Gateway: Communication hardware connecting two or more different protocols. It translates one protocol into equivalent concepts for the other protocol. In BACnet applications, a gateway has BACnet on one side and non-BACnet (usually proprietary) protocols on the other side.
- EE. GIF: Abbreviation of Graphic interchange format.
- FF. Graphic Program (GP): Program used to produce images of air handler systems, fans, chillers, pumps, and building spaces. These images can be animated and/or color-coded to indicate operation of the equipment.
- GG. Graphic Sequence of Operation: It is a graphical representation of the sequence of operation, showing all inputs and output logical blocks.
- HH. I/O Unit: The section of a digital control system through which information is received and transmitted. I/O refers to analog input (AI, digital input (DI), analog output (AO) and digital output (DO). Analog signals are continuous and represent temperature, pressure, flow rate etc., whereas digital signals convert electronic signals to digital pulses (values), represent motor status, filter status, on-off equipment etc.
- II. I/P: a method for conveying and routing packets of information over LAN paths. User Datagram Protocol (UDP) conveys information to "sockets" without confirmation of receipt. Transmission Control Protocol (TCP) establishes "sessions", which have end-to-end confirmation and guaranteed sequence of delivery.
- JJ. JPEG: A standardized image compression mechanism stands for Joint Photographic Experts Group, the original name of the committee that wrote the standard.
- KK. Local Area Network (LAN): A communication bus that interconnects operator workstation and digital controllers for peer-to-peer communications, sharing resources and exchanging information.
- LL. Network Repeater: A device that receives data packet from one network and rebroadcasts to another network. No routing information is added to the protocol.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- MM. MS/TP: Master-slave/token-passing (ISO/IEC 8802, Part 3). It uses twisted-pair wiring for relatively low speed and low cost communication.
- NN. Native BACnet Device: A device that uses BACnet as its primary method of communication with other BACnet devices without intermediary gateways. A system that uses native BACnet devices at all levels is a native BACnet system.
- OO. Network Number: A site-specific number assigned to each network segment to identify for routing. This network number must be unique throughout the BACnet internetwork.
- PP. Object: The concept of organizing BACnet information into standard components with various associated properties. Examples include analog input objects and binary output objects.
- QQ. Object Identifier: An object property used to identify the object, including object type and instance. Object Identifiers must be unique within a device.
- RR. Object Properties: Attributes of an object. Examples include present value and high limit properties of an analog input object. Properties are defined in ASHRAE 135; some are optional and some are required. Objects are controlled by reading from and writing to object properties.
- SS. Operating system (OS): Software, which controls the execution of computer application programs.
- TT. PCX: File type for an image file. When photographs are scanned onto a personal computer they can be saved as PCX files and viewed or changed by a special application program as Photo Shop.
- UU. Peripheral: Different components that make the control system function as one unit. Peripherals include monitor, printer, and I/O unit.
- VV. Peer-to-Peer: A networking architecture that treats all network stations as equal partners- any device can initiate and respond to communication with other devices.
- WW. PICS: Protocol Implementation Conformance Statement, describing the BACnet capabilities of a device. All BACnet devices have published PICS.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- XX. PID: Proportional, integral, and derivative control, used to control modulating equipment to maintain a setpoint.
- YY. Repeater: A network component that connects two or more physical segments at the physical layer.
- ZZ. Router: a component that joins together two or more networks using different LAN technologies. Examples include joining a BACnet Ethernet LAN to a BACnet MS/TP LAN.
- AAA. Sensors: devices measuring state points or flows, which are then transmitted back to the DDC system.
- BBB. Thermostats : devices measuring temperatures, which are used in control of standalone or unitary systems and equipment not attached to the DDC system.

1.4 QUALITY ASSURANCE

- A. Criteria:
 - 1. Single Source Responsibility of subcontractor: Either the DDC Contractor or the System Integrator shall obtain hardware and software supplied under this Section and delegate the responsibility to a single source controls installation subcontractor. The Integration subcontractor shall be responsible for the complete design, installation, integration, and commissioning of the system. The controls subcontractor shall be in the business of design, installation and service of such building automation control systems similar in size and complexity.
 - 2. Equipment and Materials: Equipment and materials shall be cataloged products of manufacturers regularly engaged in production and installation of HVAC control systems. Products shall be manufacturer's latest standard design and have been tested and proven in actual use.
 - 3. The controls subcontractor shall provide a list of no less than five similar projects which have building control systems as specified in this Section. These projects must be on-line and functional such that the Department of Veterans Affairs (VA) representative could observe the control systems in full operation.
 - 4. The controls subcontractor shall have an in-place facility within 50 miles with technical staff, spare parts inventory for the next five

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- (5) years, and necessary test and diagnostic equipment to support the control systems.
5. The controls subcontractor shall have minimum of three years of experience in design and installation of building automation systems similar in performance to those specified in this Section. Provide evidence of experience by submitting resumes of the project manager, the local branch manager, project engineer, the application engineering staff, and the electronic technicians who would be involved with the supervision, the engineering, and the installation of the control systems. Training and experience of these personnel shall not be less than three years. Failure to disclose this information will be a ground for disqualification of the supplier.
6. Provide a competent and experienced Project Manager employed by the Controls Contractor. The Project Manager shall be supported as necessary by other Contractor employees in order to provide professional engineering, technical and management service for the work. The Project Manager shall attend scheduled Project Meetings as required and shall be empowered to make technical, scheduling and related decisions on behalf of the Controls Contractor.
- B. Codes and Standards:
1. All work shall conform to the applicable Codes and Standards.
2. Electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference, and be so labeled.

1.5 PERFORMANCE

- A. The system shall conform to the following:
1. Graphic Display: The system shall display up to four (4) graphics on a single screen with a minimum of twenty (20) dynamic points per graphic. All current data shall be displayed within ten (10) seconds of the request.
2. Graphic Refresh: The system shall update all dynamic points with current data within eight (8) seconds. Data refresh shall be automatic, without operator intervention.
3. Object Command: The maximum time between the command of a binary object by the operator and the reaction by the device shall be

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- two(2) seconds. Analog objects shall start to adjust within two (2) seconds.
4. Object Scan: All changes of state and change of analog values shall be transmitted over the high-speed network such that any data used or displayed at a controller or work-station will be current, within the prior six (6) seconds.
 5. Alarm Response Time: The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed (10) seconds.
 6. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every (5) seconds. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
 7. Multiple Alarm Annunciations: All workstations on the network shall receive alarms within five (5) seconds of each other.
 8. Performance: Programmable Controllers shall be able to execute DDC PID control loops at a selectable frequency from at least once every one (1) second. The controller shall scan and update the process value and output generated by this calculation at this same frequency.
 9. Reporting Accuracy: Listed below are minimum acceptable reporting end-to-end accuracies for all values reported by the specified system:

Measured Variable	Reported Accuracy
Space temperature	±0.5 degrees C (±1 degrees F)
Ducted air temperature	±0.5 degrees C [±1 degrees F]
Outdoor air temperature	±1.0 degrees C [±2 degrees F]
Dew Point	±1.5 degrees C [±3 degrees F]
Water temperature	±0.5 degrees C [±1 degrees F]
Relative humidity	±2 percent RH
Water flow	±1 percent of reading
Air flow (terminal)	±10 percent of reading
Air flow (measuring stations)	±5 percent of reading
Carbon Monoxide (CO)	±5 percent of reading
Carbon Dioxide (CO ₂)	±50 ppm

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

Air pressure (ducts)	± 25 Pa [± 0.1 inch wg]
Air pressure (space)	± 0.3 Pa [± 0.001 inch wg]
Water pressure	± 2 percent of full scale *Note 1
Electrical Power	± 0.5 percent of reading

Note 1: for both absolute and differential pressure

10. Control stability and accuracy: Control sequences shall maintain measured variable at setpoint within the following tolerances:

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	± 50 Pa (± 0.2 inch wg)	0-1.5 kPa (0-6 inch wg)
Air Pressure	± 3 Pa (± 0.01 inch wg)	-25 to 25 Pa (-0.1 to 0.1 inch wg)
Airflow	± 10 percent of full scale	
Space Temperature	$\pm 1.0^{\circ}\text{C}$ (± 2.0 degrees F)	
Duct Temperature	$\pm 1.5^{\circ}\text{C}$ (± 3 degrees F)	
Humidity	± 5 percent RH	MRI, SPS, PHARMACY
Fluid Pressure	± 10 kPa (± 1.5 psig)	0-1 MPa (1-150 psig)
Fluid Pressure	± 250 Pa (± 1.0 inch wg)	0-12.5 kPa (0-50 inch wg) differential

11. Extent of direct digital control: control design shall allow for at least the points indicated on the points lists on the drawings.

1.6 WARRANTY

- A. Labor and materials for control systems shall be warranted for a period as specified under Warranty in FAR clause 52.246-21.
- B. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no cost or reduction in service to the owner. The system includes all computer equipment, transmission equipment, and all sensors and control devices.
- C. The on-line support service shall allow the Controls supplier to dial out over telephone lines to or connect via (through password-limited access) VPN through the internet to monitor and control the facility's building automation system. This remote connection to the facility shall be within two (2) hours of the time that the problem is reported.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

This coverage shall include normal business hours, after business hours, weekend and holidays. If the problem cannot be resolved with on-line support services, the Controls supplier shall dispatch the qualified personnel to the job site to resolve the problem within 8 hours after the problem is reported.

- D. Controls subcontractor shall be responsible for temporary operations and maintenance of the control systems during the construction period until final commissioning, training of facility operators and acceptance of the project by VA.

1.7 SUBMITTALS

- A. Submit shop drawings in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC", with applicable paragraph identification.
- C. Manufacturer's Literature and Data Including:
1. A wiring diagram for each type of input device and output device including DDC controllers, modems, repeaters, etc. Diagram shall show how the device is wired and powered, showing typical connections at the digital controllers and each power supply, as well as the device itself. Show for all field connected devices, including but not limited to, control relays, motor starters, electric or electronic actuators, and temperature pressure, flow and humidity sensors and transmitters.
 2. A diagram of each terminal strip, including digital controller terminal strips, terminal strip location, termination numbers and the associated pointnames.
 3. Control dampers and control valves schedule, including the size and pressure drop.
 4. Control air-supply components, and computations for sizing compressors, receivers and main air-piping, if pneumatic controls are furnished.
 5. Catalog cut sheets of all equipment used. This includes, but is not limited to software (by manufacturer and by third parties), DDC controllers, panels, peripherals, airflow measuring stations and associated components, and auxiliary control devices such as

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

sensors, actuators, and control dampers. When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted. Each submitted piece of literature and drawings should clearly reference the specification and/or drawings that it supposed to represent.

6. Sequence of operations for each system and the associated control diagrams. Equipment and control labels shall correspond to those shown on the drawings.
 7. Color prints of proposed graphics with a list of points for display.
 8. Furnish a BACnet Protocol Implementation Conformance Statement (PICS) for each BACnet-compliant device.
 9. Schematic wiring diagrams for all control, communication and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show all interface wiring to the control system.
 10. An instrumentation list for each controlled system. Each element of the controlled system shall be listed in table format. The table shall show element name, type of device, manufacturer, model number, and product data sheet number.
 11. Riser diagrams of wiring between central control unit (CCU) and all control panels.
 12. Plan drawings showing routing of LAN and locations of control panels, controllers, routers, gateways, ECC, and larger controlled devices.
 13. Construction details for all installed conduit, cabling, raceway, cabinets, and similar. Construction details of all penetrations and their protection.
 14. Quantities of submitted items may be reviewed but it is the responsibility of the contractor administered by this Section of the technical specifications to provide sufficient quantities for a complete and working system.
- D. Product Certificates: Compliance with Article, QUALITY ASSURANCE.
- E. Validation Test Plan: Along with manufacturer's literature, product certificates, wiring and functional diagrams, and sequence of

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

operations, submit for review and approval a Validation Test Plan which is specific to the work of this project and which references the specific controls component nomenclatures found in the control contractor's wiring and functional diagrams and the specific sequences of controls for this project and which describes how the contractor will implement the controls system validation and demonstration as specified in paragraph 3.2 SYSTEM VALIDATION AND DEMONSTRATION found in this section.

- F. Licenses: Provide licenses for all software residing on and used by the Controls Systems, ECC, and portable OWS and transfer these licenses to the Owner prior to completion.
- G. As Built Control Drawings:
 - 1. Furnish three (3) copies of as-built drawings for each control system. The documents shall be submitted for approval prior to final completion.
 - 2. Furnish one (1) set of applicable control system prints for each mechanical system for wall mounting. The documents shall be submitted for approval prior to final completion.
 - 3. Furnish one (1) CD-ROM in CAD DWG and/or .DXF format for the drawings noted in subparagraphs above.
- H. Operation and Maintenance (O/M) Manuals):
 - 1. Submit in accordance with Article, INSTRUCTIONS, in Specification Section 01 00 00, GENERAL REQUIREMENTS.
 - 2. Include the following documentation:
 - a. General description and specifications for all components, including logging on/off, alarm handling, producing trend reports, overriding computer control, and changing set points and other variables.
 - b. Detailed illustrations of all the control systems specified for ease of maintenance and repair/replacement procedures, and complete calibration procedures.
 - c. One copy of the final version of all software provided including operating systems, programming language, operator workstation software, and graphics software.
 - d. Complete troubleshooting procedures and guidelines for all systems.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- e. Complete operating instructions for all systems.
 - f. Recommended preventive maintenance procedures for all system components including a schedule of tasks for inspection, cleaning and calibration. Provide a list of recommended spare parts needed to minimize downtime.
 - g. Training Manuals: Submit the course outline and training material to the Owner for approval three (3) weeks prior to the training to VA facility personnel. These persons will be responsible for maintaining and the operation of the control systems, including programming. The Owner reserves the right to modify any or all of the course outline and training material.
 - h. Licenses, guaranty, and other pertaining documents for all equipment and systems.
- I. Submit Performance Report to COR prior to final inspection.

1.8 INSTRUCTIONS

- A. Instructions to VA operations personnel: Perform in accordance with Article, INSTRUCTIONS, in Specification Section 01 00 00, GENERAL REQUIREMENTS, and as noted below. Contractor shall also video tape instruction sessions noted below.
- 1. First Phase: Formal instructions to the VA facilities personnel for a total of 16 hours, given in multiple training sessions (each no longer than four hours in length), conducted sometime between the completed installation and prior to the performance test period of the control system, at a time mutually agreeable to the Contractor and the VA.
 - 2. Second Phase: This phase of training shall comprise of on the job training during startup, checkout period, and performance test period. VA facilities personnel will work with the Contractor's installation and test personnel on a daily basis during startup and checkout period. During the performance test period, controls subcontractor will provide 8 hours of instructions, given in multiple training sessions (each no longer than four hours in length), to the VA facilities personnel.
 - 3. The O/M Manuals shall contain approved submittals as outlined in Article 1.7, SUBMITTALS. The Controls subcontractor will review the

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

manual contents with VA facilities personnel during second phase of training.

4. Training shall be given by direct employees of THE CONTROLS system subcontractor.

1.9 PROJECT CONDITIONS (ENVIRONMENTAL CONDITIONS OF OPERATION)

- A. The ECC and peripheral devices and system support equipment shall be designed to operate in ambient condition of 20 to 35 degrees C (65 to 90 degrees F) at a relative humidity of 20 to 80 percent non-condensing.
- B. The Controllers used outdoors shall be mounted in NEMA 4 waterproof enclosures, and shall be rated for operation at -40 to 65 degrees C (-40 to 150 degrees F).
- C. All electronic equipment shall operate properly with power fluctuations of plus 10 percent to minus 15 percent of nominal supply voltage.
- D. Sensors and controlling devices shall be designed to operate in the environment, which they are sensing or controlling.

1.10 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standards will govern.

- B. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):

135-2020.....BACnet A Data Communication Protocol for
Building Automation and Control Networks

147-2019.....Reducing the Release of Halogenated
Refrigerants from Refrigerating and Air-
Conditioning Equipment and Systems

- C. Federal Communication Commission (FCC):

Rules and Regulations Title 47 Chapter 1-2014 Part 15: Radio Frequency
Devices

- D. Institute of Electrical and Electronic Engineers (IEEE):

802.3-2018.....Standard for Ethernet

- E. National Fire Protection Association (NFPA):

70-2020.....National Electric Code

PART 2 - PRODUCTS

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

2.1 MATERIALS

- A. Use new products that the manufacturer is currently manufacturing and that have been installed in a minimum of 25 installations. Spare parts shall be available for at least five years after completion of this contract.

2.2 CONTROLS SYSTEM ARCHITECTURE

- A. General
1. The Controls Systems shall consist of multiple Nodes and associated equipment connected by industry standard digital and communication network arrangements.
 2. The ECC, building controllers and principal communications network equipment shall be standard products of recognized major manufacturers available through normal PC and computer vendor channels - not "Clones" assembled by a third-party subcontractor.
 3. The networks shall, at minimum, comprise, as necessary, the following:
 - a. A fixed ECC and a portable operator's terminal.
 - b. Network computer processing, data storage and BACnet-compliant communication equipment including Servers and digital data processors.
 - c. BACnet-compliant routers, bridges, switches, hubs, modems, gateways, interfaces and similar communication equipment.
 - d. Active processing BACnet-compliant building controllers connected to other BACnet-compliant controllers together with their power supplies and associated equipment.
 - e. Addressable elements, sensors, transducers and end devices.
 - f. Third-party equipment interfaces and gateways as described and required by the Contract Documents.
 - g. Other components required for a complete and working Control Systems as specified.
- B. The Specifications for the individual elements and component subsystems shall be minimum requirements and shall be augmented as necessary by the Contractor to achieve both compliance with all applicable codes, standards, and to meet all requirements of the Contract Documents.
- C. Network Architecture

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

1. The Controls communication network shall utilize BACnet communications protocol operating over a standard Ethernet LAN and operate at a minimum speed of 100 Mb/sec.
2. The networks shall utilize only copper and optical fiber communication media as appropriate and shall comply with applicable codes, ordinances and regulations.
3. All necessary telephone lines, ISDN lines and internet Service Provider services and connections will be provided by the VA.

D. Third Party Interfaces:

1. The contractor administered by this Section of the technical specifications shall include necessary hardware, equipment, software and programming to allow data communications between the controls systems and building systems supplied by other trades.
2. Other manufacturers and contractors supplying other associated systems and equipment shall provide their necessary hardware, software and startup at their cost and shall cooperate fully with the contractor administered by this Section of the technical specifications in a timely manner and at their cost to ensure complete functional integration.

E. Servers:

1. Provide data storage server(s) to archive historical data including trends, alarm and event histories and transaction logs.
2. Equip these server(s) with the same software tool set that is located in the BACnet building controllers for system configuration and custom logic definition and color graphic configuration.
3. Access to all information on the data storage server(s) shall be through the same browser functionality used to access individual nodes. When logged onto a server the operator will be able to also interact with any other controller on the control system as required for the functional operation of the controls systems. The contractor administered by this Section of the technical specifications shall provide all necessary digital processor programmable data storage server(s).
4. These server(s) shall be utilized for controls systems application configuration, for archiving, reporting and trending of data, for operator transaction archiving and reporting, for network

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

information management, for alarm annunciation, for operator interface tasks, for controls application management and similar.

2.3 COMMUNICATION

- A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135, BACnet.
 - 1. The Data link / physical layer protocol between the ECC and all B-BC's (for communication) acceptable to the VA throughout its facilities is Ethernet (ISO 8802-3) and BACnet/IP.
 - 2. The MS/TP data link / physical layer protocol is prohibited to the VA in any new BACnet network or sub-network in its healthcare or lab facilities.
- B. Each controller shall have a communication port for connection to an operator interface.
- C. Project drawings indicate remote buildings or sites to be connected by a nominal 56,000 baud modem over voice-grade telephone lines. In each remote location a modem and field device connection shall allow communication with each controller on the internetwork as specified in Paragraph D.
- D. Internetwork operator interface and value passing shall be transparent to internetwork architecture.
 - 1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, reports, system software, and custom programs shall be viewable and editable from each internet controller.
 - 2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute specified control system operation. An authorized operator shall be able to edit cross-controller links by typing a standard object address.
- E. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

wiring. Expansion shall not require operator interface hardware additions or software revisions.

- F. ECCs and Controllers with real-time clocks shall use the BACnet Time Synchronization service. The system shall automatically synchronize system clocks daily from an operator-designated device via the internetwork. The system shall automatically adjust for daylight savings and standard time as applicable.

2.4 ENGINEERING CONTROL CENTER (ECC)

- A. The ECC shall reside on a high-speed network with controllers as shown on system drawings. The ECC and each standard browser connected to server shall be able to access all system information.
- B. ECC and controllers shall communicate using BACnet protocol. ECC and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ASHRAE/ANSI 135, BACnet Annex J.
- C. Hardware: ECC shall conform to the BACnet Advanced Workstation (B-AWS) Profile and shall be BTL-Listed as a B-AWS device.
1. ECC shall be based on commercially available server grade hardware. Computers based on desktop architectures shall not be permitted. ECC shall have remote management capabilities.
 2. Processor(s):
 - a. Processors shall be either Intel Xeon or AMD EPYC chips sets designed specifically for server use. Desktop processors will not be allowed.
 - b. Minimum core count shall be 16 cores. Each Core shall be capable of executing 2 threads simultaneously.
 - c. Minimum base clock speed shall be 3.0 GHz
 3. Memory:
 - a. Engineering Control Center shall be equipped with a minimum of 32G of DDR4 Error Correcting Code (ECC) memory. After installation of required 32G of RAM, the motherboard must still have a minimum of 2 DIMM slots open for expansion. Motherboard shall be capable of minimum of 64GB of ECC memory.
 - b. Minimum speed shall be 2133MHz for memory
 4. Storage:

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- a. ECC shall be equipped with a RAID capable drive controller capable of handling at least 8 internal, hot swappable drives.
 - b. All installed drives shall be "Enterprise Class" drives designed specifically for server use.
 - c. Minimum configuration shall consist of 6 drives in 2 separate RAID arrays:
 - 1) The operating system shall be stored on a RAID 1 array comprising of 2 drives with each drive having a minimum capacity of 1TB each.
 - 2) The B-AWS software and all its related databases shall be stored in RAID 5 array consisting of 4 drives with each drive have a minimum of 4TB capacity for a minimum storage capacity of 12TB's.
 - 3) An alternative configuration for the 2 RAID arrays described above is 8 drives arrayed in a RAID 10 configuration. In this case the OS RAID array would consist of 4 drives of 1TB minimum each, and the B-AWS RAID array consisting of 4 drives of 16TB minimum each. This configuration would provide faster write times and much quicker rebuild times in the event of a drive failure.
 - d. ECC will include an 16X DVD R/W drive
5. Case:
- a. Case shall have space for a minimum of 8 hot swap 3.5 inch hard drives and one internal optical drive
 - b. Real-time clock:
 - 1) Accuracy: Plus or minus 1 minute per month.
 - 2) Time Keeping Format: 24-hour time format including seconds, minutes, hours, date, day, and month; automatic reset by software.
 - 3) Clock shall function for one year without power.
 - 4) Provide automatic time correction once every 24 hours by synchronizing clock with the Time Service Department of the U.S. Naval Observatory.
 - c. Serial ports: Four USB ports and two RS-232-F serial ports for general use, with additional ports as required. Data transmission rates shall be selectable under program control.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- d. Parallel port: Enhanced.
- e. Sound card: For playback and recording of digital WAV sound files associated with audible warning and alarm functions.
- f. Color monitor: PC compatible, not less than 22 inches, LCD type, with a minimum resolution of 1280 by 1024 pixels, non-interlaced, and a maximum dot pitch of 0.28 mm.
- g. Keyboard: Minimum of 64 characters, standard ASCII character set based on ANSI INCITS 154.
- h. Mouse: Standard, compatible with installed software.
- i. Removable disk storage: Include the following, each with appropriate controller:
 - 1) Minimum 1 TB removable hard disk, maximum average access time of 10 ms.
- j. Network interface card (NIC): integrated 10-100-1000 Base-TX Ethernet NIC with an RJ45 connector or a 100Base-FX Ethernet NIC with an SC/ST connector.
- 6. Cable modem: 42.88 MBit/s, DOCSIS 2.0 Certified, also backwards compatible with DOCSIS 1.1/1.0 standards. Provide Ethernet or USB connectivity.
- 7. Audible Alarm: Manufacturer's standard.
- 8. Printers:
 - a. Provide a dedicated, minimum resolution 600 dpi, color laser printer, connected to the ECC through a USB interface.
 - 1) If a network printer is used instead of this dedicated printer, it shall have a 100Base-T interface with an RJ45 connection and shall have a firmware print spooler compatible with the Operating System print spooler.
 - 2) RAM: 512 MB, minimum.
 - 3) Printing Speed: Minimum twenty-six pages per minute (color); minimum 30 pages per minute (black/white).
 - 4) Paper Handling: Automatic sheet feeder with 250-sheet x 8.5 inch x 11 inch paper cassette and with automatic feed.
 - b. Provide a dedicated black/white tractor-feed dot matrix printer for status/alarm message printing, minimum 10 characters per inch, minimum 160 characters per second, connected to the ECC through a USB interface.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- 1) Paper: One box of 2000 sheets of 8-1/2 x 11 inch multi-fold type printer paper
9. Self-contained uninterruptible power supply (UPS):
 - a. Size: Provide a minimum of six hours of operation of ECC equipment, including two hours of alarm printer operation.
 - b. Batteries: Sealed, valve regulated, recombinant, lead calcium.
 - c. Accessories:
 - 1) Transient voltage suppression.
 - 2) Input-harmonics reduction.
 - 3) Rectifier/charger.
 - 4) Battery disconnect device.
 - 5) Static bypass transfer switch.
 - 6) Internal maintenance bypass/isolation switch.
 - 7) External maintenance bypass/isolation switch.
 - 8) Output isolation transformer.
 - 9) Remote UPS monitoring.
 - 10) Battery monitoring.
 - 11) Remote battery monitoring.
- D. ECC Software:
 1. Provide for automatic system database save and restore on the ECC's hard disk a copy of the current database of each Controller. This database shall be updated whenever a change is made in any system panel. In the event of a database loss in a building management panel, the ECC shall automatically restore the database for that panel. This capability may be disabled by the operator.
 2. Provide for manual database save and restore. An operator with proper clearance shall be able to save the database from any system panel. The operator also shall be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.
 3. Provide a method of configuring the system. This shall allow for future system changes or additions by users with proper clearance.
 4. Operating System. Furnish a concurrent multi-tasking operating system. The operating system also shall support the use of other common software applications. Acceptable operating systems are Windows Server 2019, Linux, and UNIX.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

5. System Graphics. The operator workstation software shall be graphically oriented. The system shall allow display of up to 10 graphic screens at once for comparison and monitoring of system status. Provide a method for the operator to easily move between graphic displays and change the size and location of graphic displays on the screen. The system graphics shall be able to be modified while on-line. An operator with the proper password level shall be able to add, delete, or change dynamic objects on a graphic. Dynamic objects shall include analog and binary values, dynamic text, static text, and animation files. Graphics shall have the ability to show animation by shifting image files based on the status of the object.
6. Custom Graphics. Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be a graphically based system that uses the mouse to create and modify graphics that are saved in industry standard formats such as PCX, TIFF, and GEM. The graphics generation package also shall provide the capability of capturing or converting graphics from other programs such as Designer or AutoCAD.
7. Graphics Library. Furnish a complete library of standard HVAC equipment graphics such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library also shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program.
8. The Controls Systems Operator Interfaces shall be user friendly, readily understood and shall make maximum use of colors, graphics, icons, embedded images, animation, text based information and data visualization techniques to enhance and simplify the use and understanding of the displays by authorized users at the ECC. The operating system shall be Windows 10 latest version, or better, and shall support the third party software.
9. Provide graphical user software, which shall minimize the use of keyboard through the use of the mouse and "point and click" approach to menu selection.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

10. The software shall provide a multi-tasking type environment that will allow the user to run several applications simultaneously. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able automatically export data to and work in Microsoft Word, Excel, and other Windows based software programs, while concurrently on-line system alarms and monitoring information.
11. On-Line Help. Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.
12. User access shall be protected by a flexible and Owner re-definable software-based password access protection. Password protection shall be multi-level and partition able to accommodate the varied access requirements of the different user groups to which individual users may be assigned. Provide the means to define unique access privileges for each individual authorized user. Provide the means to on-line manage password access control under the control of a project specific Master Password. Provide an audit trail of all user activity on the Controls Systems including all actions and changes.
13. The system shall be completely field-programmable from the common operator's keyboard thus allowing hard disk storage of all data automatically. All programs for the CUs shall be able to be downloaded from the hard disk. The software shall provide the following functionality as a minimum:
 - a. Point database editing, storage and downloading of controller databases.
 - b. Scheduling and override of building environmental control systems.
 - c. Collection and analysis of historical data.
 - d. Alarm reporting, routing, messaging, and acknowledgement.
 - e. Definition and construction of dynamic color graphic displays.
 - f. Real-time graphical viewing and control of environment.
 - g. Scheduling trend reports.
 - h. Program editing.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- i. Operating activity log and system security.
 - j. Transfer data to third party software.
14. Provide functionality such that using the least number of steps to initiate the desired event may perform any of the following simultaneously:
- a. Dynamic color graphics and graphic control.
 - b. Alarm management.
 - c. Event scheduling.
 - d. Dynamic trend definition and presentation.
 - e. Program and database editing.
 - f. Each operator shall be required to log on to the system with a username and password to view, edit or delete the data. System security shall be selectable for each operator, and the password shall be able to restrict the operator's access for viewing and changing the system programs. Each operator shall automatically be logged off the system if no keyboard or mouse activity is detected for a selected time.
15. Graphic Displays:
- a. The workstation shall allow the operator to access various system schematics and floor plans via a graphical penetration scheme, menu selection, or text-based commands. Graphic software shall permit the importing of AutoCAD or scanned pictures in the industry standard format (such as PCX, BMP, GIF, and JPEG) for use in the system.
 - b. System Graphics shall be project specific and schematically correct for each system. (i.e.: coils, fans, dampers located per equipment supplied with project.) Standard system graphics that do not match equipment or system configurations are prohibited. Operator shall have capability to manually operate the entire system from each graphic screen at the ECC. Each system graphic shall include a button/tab to a display of the applicable sequence of operation.
 - c. Dynamic temperature values, humidity values, flow rates, and status indication shall be shown in their locations and shall automatically update to represent current conditions without

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- operator intervention and without pre-defined screen refresh values.
- d. Color shall be used to indicate status and change in status of the equipment. The state colors shall be user definable.
 - e. A clipart library of HVAC equipment, such as chillers, boilers, air handling units, fans, terminal units, pumps, coils, standard ductwork, piping, valves and laboratory symbols shall be provided in the system. The operator shall have the ability to add custom symbols to the clipart library.
 - f. A dynamic display of the site-specific architecture showing status of the controllers, the ECC and network shall be provided.
 - g. The windowing environment of the workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of graphic associated with an alarm to be viewed without interrupting work in progress. The graphic system software shall also have the capability to split screen, half portion of the screen with graphical representation and the other half with sequence of operation of the same HVAC system.
16. Trend reports shall be generated on demand or pre-defined schedule and directed to monitor display, printers or disk. As a minimum, the system shall allow the operator to easily obtain the following types of reports:
- a. A general list of all selected points in the network.
 - b. List of all points in the alarm.
 - c. List of all points in the override status.
 - d. List of all disabled points.
 - e. List of all points currently locked out.
 - f. List of user accounts and password access levels.
 - g. List of weekly schedules.
 - h. List of holiday programming.
 - i. List of limits and dead bands.
 - j. Custom reports.
 - k. System diagnostic reports, including, list of digital controllers on the network.
 - l. List of programs.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

17. Electrical Reports

- a. Electrical Meter Report: Provide a monthly report showing the daily electrical consumption and peak electrical demand with time and date stamp for each building meter.
- b. Provide an annual (12-month) summary report showing the monthly electrical consumption and peak demand with time and date stamp for each meter.

18. Scheduling and Override:

- a. Provide override access through menu selection from the graphical interface and through a function key.
- b. Provide a calendar type format for time-of-day scheduling and overrides of building control systems. Schedules reside in the ECC. The digital controllers shall ensure equipment time scheduling when the ECC is off-line. The ECC shall not be required to execute time scheduling. Provide the following spreadsheet graphics as a minimum:
 - 1) Weekly schedules.
 - 2) Zone schedules, minimum of 100 zones.
 - 3) Scheduling up to 365 days in advance.
 - 4) Scheduled reports to print at workstation.

19. Collection and Analysis of Historical Data:

- a. Provide trending capabilities that will allow the operator to monitor and store records of system activity over an extended period. Points may be trended automatically on time-based intervals or change of value, both of which shall be user definable. The trend interval could be five (5) minutes to 120 hours. Trend data may be stored on hard disk for future diagnostic and reporting. Additionally trend data may be archived to network drives or removable disk media for off-site retrieval.
- b. Reports may be customized to include individual points or predefined groups of at least six points. Provide additional functionality to allow pre-defined groups of up to 250 trended points to be easily accessible by other industry standard word processing and spreadsheet packages. The reports shall be time and date stamped and shall contain a report title and the name of the facility.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- c. System shall have the set up to generate spreadsheet reports to track energy usage and cost based on weekly or monthly interval, equipment run times, equipment efficiency, and/or building environmental conditions.
 - d. Provide additional functionality that will allow the operator to view real time trend data on trend graph displays. A minimum of 20 points may be graphed regardless of whether they have been predefined for trending. In addition, the user may pause the graph and take snapshots of the screens to be stored on the workstation disk for future reference and trend analysis. Exact point values may be viewed, and the graph may be printed. Operator shall be able to command points directly on the trend plot by double clicking on the point.
20. Alarm Management:
- a. Alarm routing shall allow the operator to send alarm notification to selected printers or operator workstation based on time of day, alarm severity, or point type.
 - b. Alarm notification shall be provided via two alarm icons, to distinguish between routine, maintenance type alarms and critical alarms. The critical alarms shall display on the screen at the time of its occurrence, while others shall display by clicking on their icon.
 - c. Alarm display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message in English language. The operator shall be able to sort out the alarms.
 - d. Alarm messages shall be customized for each point to display detailed instructions to the operator regarding actions to take in the event of an alarm.
 - e. An operator with proper security level access may acknowledge and clear the alarm. All that have not been cleared shall be archived at workstation disk.
21. Remote Communications: The system shall have the ability to dial out in the event of an alarm. Receivers shall include operator workstations, e-mail addresses, and alpha-numeric pagers. The alarm

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

message shall include the name of the calling location, the device that generated the alarm, and the alarm message itself.

22. System Configuration:

- a. Network control strategies shall not be restricted to a single digital controller but shall be able to include data from all other network devices to allow the development of global control strategies.
- b. Provide automatic backup and restore of all digital controller databases on the workstation hard disk. In addition to all backup data, all databases shall be performed while the workstation is on-line without disturbing other system operations.

2.5 PORTABLE OPERATOR'S TERMINAL (POT) (NOT USED)

2.6 BACnet PROTOCOL ANALYZER (NOT USED)

2.7 NETWORK AND DEVICE NAMING CONVENTION

A. Network Numbers

1. BACnet network numbers shall be based on a "facility code, network" concept. The "facility code" is the VAMC's or VA campus' assigned numeric value assigned to a specific facility or building. The "network" typically corresponds to a "floor" or other logical configuration within the building. BACnet allows 65535 network numbers per BACnet internet work.
2. The network numbers are thus formed as follows: "Net #" = "FFFNN" where:
 - a. FFF = Facility code (see below)
 - b. NN = 00-99 This allows up to 100 networks per facility or building

B. Device Instances

1. BACnet allows 4194305 unique device instances per BACnet internet work. Using Agency's unique device instances are formed as follows: "Dev #" = "FFFNNDD" where
 - a. FFF and N are as above and
 - b. DD = 00-99, this allows up to 100 devices per network.
2. Note Special cases, where the network architecture of limiting device numbering to DD causes excessive subnet works. The device number can be expanded to DDD and the network number N can become a

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

single digit. In NO case shall the network number N and the device number D exceed 4 digits.

3. Facility code assignments:
4. 000-400 Building/facility number
5. Note that some facilities have a facility code with an alphabetic suffix to denote wings, related structures, etc. The suffix will be ignored. Network numbers for facility codes greater than 400 will be assigned in the range 000-399.

C. Device Names

1. Name the control devices based on facility name, location within a facility, the system or systems that the device monitors and/or controls, or the area served. The intent of the device naming is to be easily recognized. Names can be up to 254 characters in length, without embedded spaces. Provide the shortest descriptive, but unambiguous, name. For example, in building #123 prefix the number with a "B" followed by the building number, if there is only one chilled water pump "CHWP-1", a valid name would be "B123.CHWP.1.STARTSTOP". If there are two pumps designated "CHWP-1", one in a basement mechanical room (Room 0001) and one in a penthouse mechanical room (Room PH01), the names could be "B123.R0001.CHWP.1.STARTSTOP" or "B123.RPH01.CHWP.1.STARTSTOP". In the case of unitary controllers, for example a VAV box controller, a name might be "B123.R101.VAV". These names should be used for the value of the "Object_Name" property of the BACnet Device objects of the controllers involved so that the BACnet name and the EMCS name are the same.

2.8 BACnet DEVICES

- A. All BACnet Devices - controllers, gateways, routers, actuators, Operator Displays, and sensors shall conform to BACnet Device Profiles and shall be BACnet Testing Laboratories (BTL) -Listed as conforming to those Device Profiles. Protocol Implementation Conformance Statements (PICSS), describing the BACnet capabilities of the Devices shall be published and available for the Devices through links in the BTL website.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

1. BACnet Building Controllers, shall conform to the BACnet B-BC Device Profile, and shall be BTL-Listed as conforming to the B-BC Device Profile. The Device's PICS shall be submitted.
2. BACnet Advanced Application Controllers shall conform to the BACnet B-AAC Device Profile and shall be BTL-Listed as conforming to the B-AAC Device Profile. The Device's PICS shall be submitted.
3. BACnet Application Specific Controllers shall conform to the BACnet B-ASC Device Profile and shall be BTL-Listed as conforming to the B-ASC Device Profile. The Device's PICS shall be submitted.
4. BACnet Smart Actuators shall conform to the BACnet B-SA Device Profile and shall be BTL-Listed as conforming to the B-SA Device Profile. The Device's PICS shall be submitted.
5. BACnet Smart Sensors shall conform to the BACnet B-SS Device Profile and shall be BTL-Listed as conforming to the B-SS Device Profile. The Device's PICS shall be submitted.
6. BACnet routers and gateways shall conform to the BACnet B-OTH Device Profile, and shall be BTL-Listed as conforming to the B-OTH Device Profile. The Device's PICS shall be submitted.

2.9 CONTROLLERS

- A. General. Provide an adequate number of BTL listed B-BC building controllers, BTL listed B-AAC, BTL listed B-ASC, BTL listed B-SA, and BTL listed B-SS's to achieve the performance specified in the Part 1 Article on "System Performance." Each of these controllers shall meet the following requirements.
1. Communication.
 - a. Each B-BC controller shall reside on a BACnet network using the ISO 8802-3 (Ethernet) Data Link/Physical layer protocol for its communications.
 - b. Each B-BC controller shall provide a service communication port using BACnet Data Link/Physical layer protocol for connection to a portable operator's terminal. If this port is not available built into the controller, contractor is to install a 4 port unmanaged switch inside the B-BC control cabinet.
 2. Keypad. A local keypad and display shall be provided for each controller. The keypad shall be provided for interrogating and

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- editing data. Provide a system security password to prevent unauthorized use of the keypad and display.
3. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
 4. Memory. The controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.
 5. The controller shall be able to operate at 90 percent to 110 percent of nominal voltage rating and shall perform an orderly shutdown less than 80 percent nominal voltage. Controller operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 watt at 1 meter (3 feet).
 6. Transformer. Power supply for the ASC must be rated at a minimum of 125 percent of B-ASC power consumption and shall be of the fused or current limiting type.
- B. Provide BTL-Listed B-ASC application specific controllers for each piece of equipment for which they are constructed. Application specific controllers shall communicate with other BACnet devices on the internetwork using the BACnet Read (Execute) Property service.
1. Each B-ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.
 2. Each B-ASC will contain sufficient I/O capacity to control the target system.
 3. Communication.
 - a. Each controller shall reside on a BACnet network using the ISO 8802-3 (Ethernet) Data Link/Physical layer protocol for its communications. Each building controller also shall perform BACnet routing if connected to a network of custom application and application specific controllers.
 - b. Each controller shall have a BACnet Data Link/Physical layer compatible connection for a laptop computer or a portable operator's tool. This connection shall be extended to a space temperature sensor port where shown.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

4. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
5. Memory. The application specific controller shall use nonvolatile memory and maintain all BIOS and programming information in the event of a power loss.
6. Immunity to power and noise. Controllers shall be able to operate at 90 percent to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent. Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 watts at 1 meter (3 feet).

C. Direct Digital Controller Software

1. The software programs specified in this section shall be commercially available, concurrent, multi-tasking operating system and support the use of software application that operates under Microsoft Windows.
2. All points shall be identified by up to 30-character point name and 16-character point descriptor. The same names shall be used at the ECC.
3. All control functions shall execute within the stand-alone control units. All new controllers installed will also include all software and/or hardware required to program, commission, or alter the sequence of operation of said controller(s). Controllers requiring software or hardware that is not commercially available will not be allowed. Installation of software and/or hardware for controller configuration will be the responsibility of the DDC contractor. COR will direct to install said hardware and/or software on either the B-AWS or portable operator terminal. The VA shall be able to customize control strategies and sequences of operations defining the appropriate control loop algorithms and choosing the optimum loop parameters without requiring the services of a DDC contractor.
4. All controllers shall be capable of being programmed to utilize stored default values for assured fail-safe operation of critical processes. Default values shall be invoked upon sensor failure or, if the primary value is normally provided by the central or another

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- CU, or by loss of bus communication. Individual application software packages shall be structured to assume a fail-safe condition upon loss of input sensors. Loss of an input sensor shall result in output of a sensor-failed message at the ECC. Each ACU and RCU shall have capability for local readouts of all functions. The UCUs shall be read remotely.
5. All DDC control loops shall be able to utilize any of the following control modes:
 - a. Two position (on-off, slow-fast) control.
 - b. Proportional control.
 - c. Proportional plus integral (PI) control.
 - d. Proportional plus integral plus derivative (PID) control. All PID programs shall automatically invoke integral wind up prevention routines whenever the controlled unit is off, under manual control of an automation system or time-initiated program.
 - e. Automatic tuning of control loops.
 6. System Security: Operator access shall be secured using individual password and operator's name. Passwords shall restrict the operator to the level of object, applications, and system functions assigned to him. A minimum of three (3) or a maximum of six (6) levels of security for operator access shall be provided.
 7. Application Software: The controllers shall provide the following programs as a minimum for the purpose of optimizing energy consumption while maintaining comfortable environment for occupants. All application software shall reside and run in the system digital controllers. Editing of the application shall occur at the ECC or via a portable operator's terminal, when it is necessary, to access directly the programmable unit.
 - a. Event Scheduling: Provide a comprehensive menu driven program to automatically start and stop designated points or a group of points according to a stored time. This program shall provide the capability to individually command a point or group of points. When points are assigned to one common load group it shall be possible to assign variable time advances/delays between each successive start or stop within that group. Scheduling shall be calendar based and advance schedules may be defined up to one

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

year in advance. Advance schedule shall override the day-to-day schedule. The operator shall be able to define the following information:

- 1) Time, day.
 - 2) Commands such as on, off, auto.
 - 3) Time delays between successive commands.
 - 4) Manual overriding of each schedule.
 - 5) Allow operator intervention.
- b. Alarm Reporting: The operator shall be able to determine the action to be taken in the event of an alarm. Alarms shall be routed to the ECC based on time and events. An alarm shall be able to start programs, login the event, print and display the messages. The system shall allow the operator to prioritize the alarms to minimize nuisance reporting and to speed operator's response to critical alarms. A minimum of six (6) priority levels of alarms shall be provided for each point.
- c. Remote Communications: The system shall have the ability to dial out in the event of an alarm to the ECC and alpha-numeric pagers. The alarm message shall include the name of the calling location, the device that generated the alarm, and the alarm message itself. The operator shall be able to remotely access and operate the system using dial up communications. Remote access shall allow the operator to function the same as local access.
- d. Maintenance Management (PM): The program shall monitor equipment status and generate maintenance messages based upon the operators defined equipment run time, starts, and/or calendar date limits. A preventative maintenance alarm shall be printed indicating maintenance requirements based on pre-defined run time. Each preventive message shall include point description, limit criteria and preventative maintenance instruction assigned to that limit. A minimum of 480-character PM shall be provided for each component of units such as air handling units.

2.10 SPECIAL CONTROLLERS (NOT USED)

2.11 SENSORS (AIR, WATER AND STEAM)

A. Sensors' measurements shall be read back to the DDC system, and shall be visible by the ECC.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

B. Temperature and Humidity Sensors shall be electronic, vibration and corrosion resistant for wall, immersion, and/or duct mounting. Provide all remote sensors as required for the systems.

1. Temperature Sensors: thermistor type for terminal units and Resistance Temperature Device (RTD) with an integral 4-20 mA or 0-10 VDC transmitter type for all other sensors.

a. Duct sensors shall be rigid or averaging type as shown on drawings. Averaging sensor shall be a minimum of 1 linear foot of sensing element for each square feet of cooling/heating coil face area.

b. Immersion sensors shall be provided with a separable well made of stainless steel, bronze or monel material. Pressure rating of well is to be consistent with the system pressure in which it is to be installed. Temperature well shall be filled with a thermal compound compatible with installed sensor.

c. All space sensors shall be equipped with in-space User set-point adjustment, override switch, numerical temperature display on sensor cover, and BACnet communication port. Match room thermostats. Provide a tooled-access cover.

d. Outdoor air temperature sensors shall have watertight inlet fittings and be shielded from direct sunlight.

e. Room security sensors shall have stainless steel cover plate with insulated back and security screws.

f. Wire: Twisted, shielded-pair cable.

g. Output Signal: 4-20 mA or 0-10 VDC.

C. Static Pressure Sensors: Non-directional, temperature compensated.

1. 4-20 mA or 0-10 VDC output signal.

2. 0 to 5 inches wg for duct static pressure range.

3. 0 to 0.25 inch wg for Building static pressure range.

D. Flow switches:

1. Shall be either paddle or differential pressure type.

a. Paddle-type switches (liquid service only) shall be UL Listed, SPDT snap-acting, adjustable sensitivity with NEMA 4 enclosure.

b. Differential pressure type switches (air or water service) shall be UL listed, SPDT snap acting, NEMA 4 enclosure, with scale range and differential suitable for specified application.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- E. Current Switches: Current operated switches shall be self powered, solid state with adjustable trip current as well as status, power, and relay command status LED indication. The switches shall be selected to match the current of the application and output requirements of the DDC systems.

2.12 CONTROL CABLES

A. General:

1. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments. Comply with Sections 27 05 26 and 26 05 26.
2. Cable conductors to provide protection against induction in circuits. Crosstalk attenuation within the System shall be in excess of -80 dB throughout the frequency ranges specified.
3. Minimize the radiation of RF noise generated by the System equipment so as not to interfere with any audio, video, data, computer main distribution frame (MDF), telephone customer service unit (CSU), and electronic private branch exchange (EPBX) equipment the System may service.
4. The as-installed drawings shall identify each cable as labeled, used cable, and bad cable pairs.
5. Label system's cables on each end. Test and certify cables in writing to the VA before conducting proof-of-performance testing. Minimum cable test requirements are for impedance compliance, inductance, capacitance, signal level compliance, opens, shorts, cross talk, noise, and distortion, and split pairs on all cables in the frequency ranges used. Make available all cable installation and test records at demonstration to the VA. All changes (used pair, failed pair, etc.) shall be posted in these records as the change occurs.
6. Power wiring shall not be run in conduit with communications trunk wiring or signal or control wiring operating at 100 volts or less.

- B. Analogue control cabling shall be not less than No. 18 AWG solid or stranded, with thermoplastic insulated conductors as specified in Section 26 05 21.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- C. Copper digital communication cable between the ECC and the B-BC and B-AAC controllers shall be 100BASE-TX Ethernet, Category 5e or 6, not less than minimum 24 American Wire Gauge (AWG) solid, Shielded Twisted Pair (STP) or Unshielded Twisted Pair (UTP), with thermoplastic insulated conductors, enclosed in a thermoplastic outer jacket, as specified in Section 27 15 00.
1. Other types of media commonly used within IEEE Std 802.3 LANs (e.g., 10Base-T and 10Base-2) shall be used only in cases to interconnect with existing media.
- D. All MS/TP communications cables for devices utilizing the EIA-485 standard must be listed for use on EIA-485 networks by the manufacturer of the cable. This requirement overrides any cable recommendation by the controller manufacturer. The use of EIA-485 communication cables shall not affect the warranty from the installing DDC contractor. Cables shall have the following characteristic:
1. Nominal Impedance: 100-130 Ohms
 2. Twisted/shielded construction of 1, 1.5, or 2 pairs depending on controller requirements.
 3. Be plenum rated when required
 4. Cables designated for use by the cable manufacturer for use in PA or Speaker systems shall not be allowed, regardless of recommendations by the controller manufacturer.
- E. Optical digital communication fiber, if used, shall be Multimode or Single mode fiber, 62.5/125 micron for multimode or 10/125 micron for single mode micron with SC or ST connectors as specified in TIA-568-C.1. Terminations, patch panels, and other hardware shall be compatible with the specified fiber and shall be as specified in Section 27 15 00. Fiber-optic cable shall be suitable for use with the 100Base-FX or the 100Base-SX standard (as applicable) as defined in IEEE Std 802.3.

2.13 THERMOSTATS AND HUMIDISTATS

- A. Room thermostats controlling unitary standalone heating and cooling devices not connected to the DDC system shall have three modes of operation (heating - null or dead band - cooling). Thermostats for patient bedrooms shall have capability of being adjusted to eliminate null or dead band. Wall mounted thermostats shall have polished or

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

brushed aluminum manufacturer's recommendation finish, setpoint range and temperature display and external adjustment:

1. Electronic Thermostats: Solid-state, microprocessor based, BACnet enabled programmable to daily, weekend, and holiday schedules.
 - a. Public Space Thermostat: Public space thermostat shall have a thermistor sensor and shall not have a visible means of set point adjustment. Adjustment shall be via the digital controller to which it is connected.
 - b. Patient Room Thermostats: thermistor with in-space User set point adjustment and an on-casing room temperature numerical temperature display.
 - c. Psychiatric Patient Room Sensors: Electronic duct sensor as noted under Article 2.4.
 - d. Battery replacement without program loss.

2.14 FINAL CONTROL ELEMENTS AND OPERATORS

- A. Fail Safe Operation: Control valves and dampers shall provide "fail safe" operation in either the normally open or normally closed position as required for freeze, moisture, and smoke or fire protection.
- B. Spring Ranges: Range as required for system sequencing and to provide tight shut-off.
- C. Power Operated Control Dampers (other than VAV Boxes): Factory fabricated, balanced type dampers. All modulating dampers shall be opposed blade type and gasketed. Blades for two-position, duct-mounted dampers shall be parallel, airfoil (streamlined) type for minimum noise generation and pressure drop.
 1. Leakage: Except as specified in subparagraph 2 below, maximum leakage in closed position shall not exceed 7 L/S (15 CFMs) differential pressure for outside air and exhaust dampers and 200 L/S/ square meter (40 CFM/square feet) at 50 mm (2 inches) differential pressure for other dampers.
 2. Frame shall be galvanized steel channel with seals as required to meet leakage criteria.
 3. Blades shall be galvanized steel or aluminum, 200 mm (8 inch) maximum width, with edges sealed as required.
 4. Bearing shall be nylon, bronze sleeve or ball type.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

5. Hardware shall be zinc-plated steel. Connected rods and linkage shall be non-slip. Working parts of joints shall be brass, bronze, nylon or stainless steel.
6. Maximum air velocity and pressure drop through free area of the dampers:
 - a. Smoke damper in air handling unit: 305 meter per minute (1000 fpm).
 - b. Duct mounted damper: 600 meter per minute (2000 fpm).
 - c. Maximum static pressure loss: 50 Pascal (0.20 inches water gauge).

D. Control Valves:

1. Valves shall be rated for a minimum of 150 percent of system operating pressure at the valve location but not less than 900 kPa (125 psig).
2. Valves 50 mm (2 inches) and smaller shall be bronze body with threaded or flare connections.
3. Valves 60 mm (2 1/2 inches) and greater shall be bronze or iron body with flanged connections.
4. Brass or bronze seats except for valves controlling media greater than 100 degrees C (210 degrees F), which shall have stainless steel seats.
5. Flow characteristics:
 - a. Three way modulating valves shall be globe pattern. Position versus flow relation shall be linear relation for steam or equal percentage for water flow control.
 - b. Two-way modulating valves shall be globe pattern. Position versus flow relation shall be linear for steam and equal percentage for water flow control.
 - c. Two-way 2-position valves shall be ball, gate or butterfly type.
6. Maximum pressure drop:
 - a. Two position steam control: 20 percent of inlet gauge pressure.
 - b. Modulating Steam Control: 80 percent of inlet gauge pressure (acoustic velocity limitation).
 - c. Modulating water flow control, greater of 3 meters (10 feet) of water or the pressure drop through the apparatus.
7. Two position water valves shall be line size.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

E. Damper and Valve Operators and Relays:

1. Electric operator shall provide full modulating control of dampers and valves. For dampers a linkage and pushrod shall be furnished for mounting the actuator on the damper frame internally in the duct, externally in the duct, externally on the duct wall, or shall be furnished with a direct-coupled design. Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel. Provide actuator heads which allow for electrical conduit attachment. The motor(s) shall have sufficient closure torque to allow for complete closure of valve or damper under pressure. Provide multiple motors as required to achieve sufficient close-off torque.
 - a. Minimum valve close-off pressure shall be equal to the system pump's dead-head pressure, minimum 50 psig for valves smaller than 4 inches.
2. Electronic damper operators: Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel. Provide actuator heads which allow for electrical conduit attachment. The motors shall have sufficient closure torque to allow for complete closure of valve or damper under pressure. Provide multiple motors as required to achieve sufficient close-off torque.
 - a. VAV Box actuator shall be mounted on the damper axle or shall be of the air valve design, and shall provide complete modulating control of the damper. The motor shall have a closure torque of 35-inch pounds minimum with full torque applied at close off to attain minimum leakage.

3. See and coordinate drawings for required control operation.

2.15 AIR FLOW CONTROL (NOT USED)

2.16 SAFETY

A. Provide hard-wired interlocked connections for such all safety devices, such as freeze stats, smoke detectors, smoke dampers, and refrigerant leak detection devices. All safety devices shall be provided with additional dry contacts and shall be connected to the DDC system for monitoring and sequencing.

03-01-23

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

1. Examine project plans for control devices and equipment locations; and report any discrepancies, conflicts, or omissions to COR for resolution before proceeding for installation.
2. Install equipment, piping, wiring /conduit parallel to or at right angles to building lines.
3. Install all equipment and piping in readily accessible locations. Do not run tubing and conduit concealed under insulation or inside ducts.
4. Mount control devices, tubing and conduit located on ducts and apparatus with external insulation on standoff support to avoid interference with insulation.
5. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
6. Run tubing and wire connecting devices on or in control cabinets parallel with the sides of the cabinet neatly racked to permit tracing.
7. Install equipment level and plumb.

B. Electrical Wiring Installation:

1. All wiring and cabling shall be installed in conduits. Install conduits and wiring in accordance with Specification Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS. Conduits carrying control wiring and cabling shall be dedicated to the control wiring and cabling: these conduits shall not carry power wiring. Provide plastic end sleeves at all conduit terminations to protect wiring from burrs.
2. Install analog signal and communication cables in conduit and in accordance with Specification Division 27 - COMMUNICATIONS. Install digital communication cables in conduit and in accordance with Specification Section 27 15 00, COMMUNICATIONS STRUCTURED CABLING.
3. Install conduit and wiring between operator workstation(s), digital controllers, electrical panels, indicating devices, instrumentation, miscellaneous alarm points, thermostats, and relays as shown on the drawings or as required under this section.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

4. Install all electrical work required for a fully functional system and not shown on electrical plans or required by electrical specifications. Where low voltage (less than 50 volt) power is required, provide suitable Class B transformers.
 5. Install all system components in accordance with local Building Code and National Electric Code.
 - a. Splices: Splices in shielded and coaxial cables shall consist of terminations and the use of shielded cable couplers. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties.
 - b. Equipment: Fit all equipment contained in cabinets or panels with service loops, each loop being at least 300 mm (12 inches) long. Equipment for fiber optics system shall be rack mounted, as applicable, in ventilated, self-supporting, code gauge steel enclosure. Cables shall be supported for minimum sag.
 - c. Cable Runs: Keep cable runs as short as possible. Allow extra length for connecting to the terminal board. Do not bend flexible coaxial cables in a radius less than ten times the cable outside diameter.
 - d. Use vinyl tape, sleeves, or grommets to protect cables from vibration at points where they pass around sharp corners, through walls, panel cabinets, etc.
 6. Conceal cables, except in mechanical rooms and areas where other conduits and piping are exposed.
 7. Permanently label or code each point of all field terminal strips to show the instrument or item served. Color-coded cable with cable diagrams may be used to accomplish cable identification.
 8. Grounding: ground electrical systems per manufacturer's written requirements for proper and safe operation.
- C. Install Sensors and Controls:
1. Temperature Sensors:
 - a. Install all sensors and instrumentation according to manufacturer's written instructions. Temperature sensor locations shall be readily accessible, permitting quick replacement and servicing of them without special skills and tools.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- b. Calibrate sensors to accuracy specified, if not factory calibrated.
 - c. Use of sensors shall be limited to its duty, e.g., duct sensor shall not be used in lieu of room sensor.
 - d. Install room sensors permanently supported on wall frame. They shall be mounted at 1.5 meter (5.0 feet) above the finished floor unless otherwise noted on the plans or drawings.
 - e. Mount sensors rigidly and adequately for the environment within which the sensor operates. Separate extended-bulb sensors form contact with metal casings and coils using insulated standoffs.
 - f. Sensors used in mixing plenum, and hot and cold decks shall be of the averaging of type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.
 - g. All pipe mounted temperature sensors shall be installed in wells.
 - h. All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor reading.
 - i. Permanently mark terminal blocks for identification. Protect all circuits to avoid interruption of service due to short-circuiting or other conditions. Line-protect all wiring that comes from external sources to the site from lightning and static electricity.
2. Pressure Sensors:
- a. Install duct static pressure sensor tips facing directly downstream of airflow.
 - b. Install high-pressure side of the differential switch between the pump discharge and the check valve.
 - c. Install snubbers and isolation valves on steam pressure sensing devices.
3. Actuators:
- a. Mount and link damper and valve actuators according to manufacturer's written instructions.
 - b. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed position.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- c. Check operation of valve/actuator combination to confirm that actuator modulates valve smoothly in both open and closed position.
- 4. Flow Switches:
 - a. Install flow switch according to manufacturer's written instructions.
 - b. Mount flow switch a minimum of 5 pipe diameters up stream and 5 pipe diameters downstream or 600 mm (2 feet) whichever is greater, from fittings and other obstructions.
 - c. Assure correct flow direction and alignment.
 - d. Mount in horizontal piping-flow switch on top of the pipe.
- D. Installation of network:
 - 1. Ethernet:
 - a. The network shall employ Ethernet LAN architecture, as defined by IEEE 802.3. The Network Interface shall be fully Internet Protocol (IP) compliant allowing connection to currently installed IEEE 802.3, Compliant Ethernet Networks.
 - b. The network shall directly support connectivity to a variety of cabling types. As a minimum provide the following connectivity: 100 Base TX (Category 5e cabling) for the communications between the ECC and the B-BC and the B-AAC controllers.
 - 2. Third party interfaces: Contractor shall integrate real-time data from building systems by other trades and databases originating from other manufacturers as specified and required to make the system work as one system.
- E. Installation of digital controllers and programming:
 - 1. Provide a separate digital control panel for each major piece of equipment, such as air handling unit, chiller, pumping unit etc. Points used for control loop reset such as outdoor air, outdoor humidity, or space temperature could be located on any of the remote control units.
 - 2. Provide sufficient internal memory for the specified control sequences and trend logging. There shall be a minimum of 25 percent of available memory free for future use.
 - 3. System point names shall be human readable, permitting easy operator interface without the use of a written point index.

03-01-23

4. Provide software programming for the applications intended for the systems specified, and adhere to the strategy algorithms provided.
5. Provide graphics for each piece of equipment and floor plan in the building. This includes each chiller, cooling tower, air handling unit, fan, terminal unit, boiler, pumping unit etc. These graphics shall show all points dynamically as specified in the point list.

3.2 SYSTEM VALIDATION AND DEMONSTRATION

A. As part of final system acceptance, a system demonstration is required (see below). Prior to start of this demonstration, the contractor is to perform a complete validation of all aspects of the controls and instrumentation system. When formal commissioning is included in the project the system validation/test shall be part of the commissioning and shall be witnessed by the CxA.

B. Validation

1. Prepare and submit for approval a validation test plan including test procedures for the performance verification tests. Test Plan shall be submitted for review with the control system submittal as indicated in paragraph 1.7 Submittals. Test Plan address all specified functions of the ECC and all specified sequences of operation. Explain in detail actions and expected results used to demonstrate compliance with the requirements of this specification. Explain the method for simulating the necessary conditions of operation used to demonstrate performance of the system. Test plan shall include a test check list to be used by the Installer's agent to check and initial that each test has been successfully completed. Deliver test plan documentation for the performance verification tests to the owner's representative 30 days prior to start of performance verification tests. Provide draft copy of operation and maintenance manual with performance verification test.
2. After approval of the validation test plan, installer shall carry out all tests and procedures therein. Installer shall completely check out, calibrate, and test all connected hardware and software to ensure that system performs in accordance with approved specifications and sequences of operation submitted. Installer shall complete and submit Test Check List.

C. Demonstration

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

1. System operation and calibration to be demonstrated by the installer in the presence of the Architect, CxA or COR on random samples of equipment as dictated by the COR. Should random sampling indicate improper work, the owner reserves the right to subsequently witness complete calibration of the system at no addition cost to the VA.
2. Make accessible, personnel to provide necessary adjustments and corrections to systems as directed by balancing agency.
3. The following witnessed demonstrations of field control equipment shall be included:
 - a. Observe HVAC systems in shut down condition. Check dampers and valves for normal position.
 - b. Test application software for its ability to communicate with digital controllers, operator workstation, and uploading and downloading of control programs.
 - c. Demonstrate the software ability to edit the control program off-line.
 - d. Demonstrate reporting of alarm conditions for each alarm and ensure that these alarms are received at the assigned location, including operator workstations.
 - e. Demonstrate ability of software program to function for the intended applications-trend reports, change in status etc.
 - f. Demonstrate via graphed trends to show the sequence of operation is executed in correct manner, and that the HVAC systems operate properly through the complete sequence of operation, e.g., seasonal change, occupied/unoccupied mode, and warm-up condition.
 - g. Demonstrate hardware interlocks and safeties functions, and that the control systems perform the correct sequence of operation after power loss and resumption of power loss.
 - h. Prepare and deliver to the VA graphed trends of all control loops to demonstrate that each control loop is stable and the set points are maintained.
 - i. Demonstrate that each control loop responds to set point adjustment and stabilizes within one (1) minute(s). Control loop trend data shall be instantaneous and the time between data points shall not be greater than one (1) minute.
4. Witnessed demonstration of ECC functions shall consist of:

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- a. Running each specified report.
- b. Display and demonstrate each data entry to show site specific customizing capability. Demonstrate parameter changes.
- c. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
- d. Execute digital and analog commands in graphic mode.
- e. Demonstrate DDC loop precision and stability via trend logs of inputs and outputs (6 loops minimum).
- f. Demonstrate Energy Management System (EMS) performance via trend logs and command trace.
- g. Demonstrate scan, update, and alarm responsiveness.
- h. Demonstrate spreadsheet/curve plot software, and its integration with database.
- i. Demonstrate on-line user guide, and help function and mail facility.
- j. Demonstrate digital system configuration graphics with interactive upline and downline load, and demonstrate specified diagnostics.
- k. Demonstrate multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
- l. Demonstrate class programming with point options of beep duration, beep rate, alarm archiving, and color banding.

3.3 STARTUP AND TESTING

- A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.
- B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.
- C. The CxA will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and CxA. Provide a minimum notice of 10 working days prior to startup and testing.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

3.4 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- B. Components provided under this section of the specification will be tested as part of a larger system.

3.5 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for 4 hours to instruct each VA personnel responsible in the operation and maintenance of the system.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

3.6 CONSTRUCTION WASTE MANAGEMENT

- A. General: Comply with Contractor's Waste Management Plan and Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.
- B. To the greatest extent possible, separate reusable and recyclable products from contaminated waste and debris in accordance with the Contractor's Waste Management Plan. Place recyclable and reusable products in designated containers and protect from moisture and contamination.

----- END -----

SECTION 23 10 00
FACILITY FUEL OIL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Diesel fuel oil and unheated burner fuel oil tanks, piping, and accessories located outside, underground or aboveground as shown on contract drawings. Refer to contract drawings for type of fuel and for tank capacities.
- B. Tank fluid level monitoring and alarm systems.
- C. Leak detection system for tanks and underground piping.
- D. Fuel oil quality maintenance system (water and particulate removal).
- E. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.
- D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
- E. Section 03 30 00, CAST-IN-PLACE CONCRETE.
- F. Section 09 91 00, PAINTING.
- G. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- H. Section 23 07 11, HVAC AND BOILER PLANT INSULATION.
- I. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- J. Section 26 42 00, CATHODIC PROTECTION.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.
- B. American Petroleum Institute (API):
RP 1631-2001.....Interior Lining and Periodic Inspection of
Underground Storage Tanks
- C. American Society of Mechanical Engineers (ASME):
B16.5-2017.....Pipe Flanges and Flanged Fittings: NPS 1/2
through NPS 24 Metric/Inch Standard.
B16.9-2018.....Factory Made Wrought Buttwelding Fittings
B16.11-2016.....Forged Fittings, Socket-Welding and Threaded

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

04-01-20

- B31.1-2018.....Power Piping
- D. American Society for Testing and Materials (ASTM):
- A36/A36M-2017.....Standard Specification for Carbon Structural Steel
- A53/A53M-2018.....Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
- A105/A105M-2014.....Standard Specification for Carbon Steel Forgings for Piping Applications
- A106/A106M-2015.....Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
- A126-04 (R2019).....Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
- A234/A234M-2015.....Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
- B62-2017.....Standard Specification for Composition Bronze or Ounce Metal Castings
- D2996-2015.....Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
- E. Federal Specifications (Fed. Spec.):
- A-A-60005-1998.....Frames, Covers, Grating, Steps, Sump and Catch Basin, Manhole
- F. NACE International (NACE):
- SP0169-2013.....Control of External Corrosion on Underground or Submerged Metallic Piping Systems
- 3/SSPC-SP62013.....Commercial Blast Cleaning
- 4/SSPC-SP72006.....Brush-off Blast Cleaning
- G. National Electrical Manufacturers Association (NEMA):
- 250-2014.....Enclosures for Electrical Equipment (1000 Volts Maximum)
- H. National Fire Protection Association (NFPA):
- 30-2018.....Flammable and Combustible Liquids Code
- 31-2019.....Standard for the Installation of Oil-Burning Equipment

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

04-01-20

70-2017.....National Electrical Code (NEC)

I. Steel Tank Institute (STI):

F001-2017.....Flameshield® Standard for Fire Tested Tanks

F841-2010.....Standard for Dual Wall Underground Steel
Storage Tanks

F894-2018.....ACT-100® Specification for External Corrosion
Protection of FRP Composite Steel Underground
Storage Tanks

F941-2015.....Fireguard: Specification for Fireguard
Protected Aboveground Storage Tanks

F961-2017.....ACT-100U Specification for External Corrosion
Protection of Composite Steel Underground
Storage Tanks

P3-2015.....Specification and Manual for External Corrosion
Protection of Underground Steel Storage Tanks

R891-2006.....Recommended Practice for Hold Down Strap
Isolation

J. Underwriters Laboratories Inc. (UL):

58-2018.....Standard for Steel Underground Tanks for
Flammable and Combustible Liquids

142-2019.....Standard for Steel Aboveground Tanks for
Flammable and Combustible Liquids

971-2019.....Standard for Nonmetallic Underground Piping for
Flammable Liquids

1316-2018.....Glass-Fiber-Reinforced Plastic Underground
Storage Tanks for Petroleum Products, Alcohols,
and Alcohol-Gasoline Mixtures

1746-2007(R2014).....Standard for External Corrosion Protection
Systems for Steel Underground Storage Tanks

2085-2019.....Standard for Protected Aboveground Tanks for
Flammable and Combustible Liquids

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in
accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND
SAMPLES.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

04-01-20

- B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 10 00, FACILITY FUEL OIL SYSTEMS", with applicable paragraph identification.
- C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
- D. Aboveground Steel Tanks, Including Vault-type Tanks:
1. Drawings of tanks, supports, ladders, platforms, heating coils, tank manholes, emergency relief vents and all accessories. Include overall dimensions and dimensional locations and sizes of pipe connections, and access openings.
 2. Recommended tank support locations.
 3. Weight of entire tank assembly, empty and flooded.
 4. Design and construction of primary tanks, insulation, secondary containment, supports, pipe connections, platforms.
 5. Application and performance data on coatings from manufacturer of coatings.
 6. Data certifying tanks are designed for surcharge loads of platforms shown.
 7. Certification of compliance with specified standards.
 8. Certification that steel tank manufacturer participates in Steel Tank Institute (STI) Quality Assurance Program.
 9. Design, construction, performance, dimensions of emergency relief vents.
- E. Fuel Piping:
1. ASTM and UL compliance.
 2. Grade, class or type, schedule number.
 3. Manufacturer.
- F. Pipe Fittings, Unions, Flanges:
1. ASTM and UL compliance.
 2. ASTM standards number.
 3. Catalog cuts.
 4. Pressure and temperature rating.
- G. Foot Valves, Check Valves, Overfill Prevention Valves:
1. Catalog cuts showing design and construction.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

04-01-20

2. Pressure and temperature ratings.
 3. Pressure loss and flow rate data.
 4. Materials of construction.
 5. Accessories.
- H. Secondary Containment System for Fuel Piping:
1. Sizes, materials, construction of containment system including end seals, sumps, coatings and pipe supports.
 2. Layout of system.
 3. Installation instructions.
 4. Design of cathodic protection system (steel casing).
- I. Leak Detection System:
1. Drawings, description and performance data on sensors, control units.
 2. Description of operation.
 3. Layout of system.
 4. Installation and operating instructions.
 5. Data on interconnecting wiring systems to be furnished.
- J. Tank Fluid Level Monitoring Instrumentation System:
1. Drawings showing instruments and in-tank sensing units, with dimensions.
 2. Design and construction of all elements of system.
 3. Installation instructions.
- K. Tank and Piping Accessories: Design, construction, and dimensions of vent caps, fill boxes, fill caps, spill containers and other accessories.
- L. Fuel Quality Maintenance System:
1. Drawings and description of all components and arrangement of system.
 2. Design and performance of pumps, filters.
 3. Catalog data and operation of control system.
 4. Installation instructions.
- M. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
1. Include complete list indicating all components of the systems.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

04-01-20

2. Include complete diagrams of the internal wiring for each item of equipment.
 3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.
- N. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- O. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 QUALITY ASSURANCE

- A. Approval by Contracting Officer is required of products or services of proposed manufacturers, suppliers and installers, and will be based on Contractor's certification that:
1. Manufacturers regularly and currently manufacture tanks, tank and piping accessories, tank fluid level monitoring and leak detection systems, and fuel quality management systems.
 2. Manufacturers of steel tanks participate in the Quality Assurance Program of the Steel Tank Institute (STI).
 3. The design and size of each item of equipment provided for this project is of current production and has been in satisfactory operation on at least three installations for approximately three years. Current models of fluid level and leak detection systems with less than three years' service experience are acceptable if similar previous models from the same manufacturer have at least three years' service experience.
- B. Apply and install materials, equipment and specialties in accordance with manufacturer's written instructions. Conflicts between the manufacturer's instructions and the contract drawings and specifications shall be referred to the COR for resolution. Provide copies of installation instructions to the COR two weeks prior to commencing installation of any item.
- C. All equipment shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components or overall assembly.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

04-01-20

- D. Tanks, Secondary Containment Systems for Piping, Plastic Piping and Containment Systems, Tank Level Monitoring Systems, Leak Detection Systems, Fuel Quality Management Systems, Cathodic Protection Systems: Authorized manufacturer's representatives shall provide onsite training of installers and supervision of the installation and testing of the equipment and systems to assure conformance to written instructions of manufacturers.
- E. Tank and piping installation contractor shall be certified as acceptable by local and state pollution control authorities.
- F. Entire installation shall conform to requirements of local and state pollution control authorities.
- G. Pipe Welding: Conform to requirements of ASME B31.1. Welders shall show evidence of qualification. Welders shall utilize a stamp to identify their work. Unqualified personnel will be rejected.
- H. Assembly of Glass Fiber Reinforced Plastic Piping: Installation personnel shall have been trained, tested and certified under a procedure approved by the manufacturer of the piping. Proof of certification, in writing, shall be provided to the COR.
- I. Where specified codes or standards conflict, consult the COR.
- J. Label of Conformance (definition): Labels of accredited testing laboratories showing conformance to the standards specified.
- K. Equipment and materials installed shall be compatible in all respects with other items being furnished and with existing items so that the result will be a safe, complete and fully operational system which conforms to contract requirements and in which no item is subject to conditions beyond its design capabilities.

1.6 AS-BUILT DOCUMENTATION

- A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- B. Submit operation and maintenance data updated to include submittal review comments, VA approved substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three-ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

04-01-20

maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

- C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement. Provide record drawings as follows:
1. As-built drawings are to be provided, with a copy of them on AutoCAD version 2014 or newer provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.
- D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.
- E. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

04-01-20

1.7 PERMITS

- A. Contractor shall obtain and complete all tank permit and registration forms required by governmental authorities.

PART 2 - PRODUCTS

2.1 UNDERGROUND STEEL TANKS (NOT USED)

2.2 ABOVEGROUND STEEL TANKS

- A. Type: Factory-fabricated all welded steel, horizontal cylindrical configuration, atmospheric pressure, internal and external corrosion protection as specified. In addition to specified requirements, tanks shall be fabricated in accordance with Steel Tank Institute (STI) design standards by manufacturer that participates in STI Quality Assurance Program.
- B. Construction:
1. ASTM A36/A36M steel, conform to UL 142. Inner and outer tanks of double wall tanks shall both conform. Provide label of conformance.
 2. Conform to NFPA 30 or NFPA 31 as applicable.
 3. Double-wall, insulation between walls, conforming to STI F941 "Fireguard" construction, and to UL 2085. Provide label of conformance.
 4. Steel dike walls and floors conforming to STI standards. Provide minimum containment of 110 percent of primary tank contents. Provide steel rain shields which cover the open areas between the tank and the dike wall.
 5. Design for surcharge load produced by tank-mounted platforms and platform loadings shown. Design tanks for saddle supports furnished by tank manufacturer.
 6. Leaks and abrasions are prohibited. Maximum permissible out-of-roundness of cylindrical shells is one percent of the diameter.
 7. Provide lifting lugs for rigging tanks.
 8. Make provisions for leak detectors to be installed at lowest part of interstitial space between walls of double-wall tanks.
- C. Platforms, Stairs, Ladders and Handrails: Provide welded steel assemblies as shown, conforming to OSHA requirements. Provide welded steel tank attachments designed to support platform framing, stairs, ladders and live and dead loadings. Clean and coat all surfaces as

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

04-01-20

specified for tank and steel dike exterior. Galvanizing is an acceptable alternative.

- D. Factory Cleaning: Clean interior and exterior of tanks and steel dikes (if furnished). Remove mill scale, dirt, rust, oil, welding debris, loose coatings and coatings incompatible with fuel stored or protective coating. Sandblast exterior in accordance with NACE 3.
- E. Factory Coating: Provide tanks and steel dikes (if furnished) with exterior coat of rust resistant metal primer, specified under Section 09 91 00, PAINTING. Coat interior from bottom of tank to 1 m (3 feet) above bottom in compliance with API RP 1631.
- F. Field Painting: Clean and coat all surfaces as specified in Section 09 91 00, PAINTING.
- G. Pipe Connections to Tanks:
 - 1. Conform to UL 142.
 - 2. Pipe sizes 50 mm (2 inches) and smaller, threaded. Pipe sizes 65 mm (2-1/2 inches) and larger, flanged, 1034 kPa (150 psig) ASME rating.
 - 3. Welded joints required on steel piping located inside tanks.
 - 4. Provide and coordinate tank connection quantities, sizes and types with requirements of tank level gauge unit; sounding rod; vent, fill, supply and return pipes; and other pipes as shown.
 - 5. On double-wall tanks, provide valved drain of interstitial space.
- H. Tank Manholes: Provide quantity shown. Bolted cover type, gasketed.
- I. Internal Ladder: Provide as shown with 50 mm x 6 mm (2 inch x 1/4 inch) sides and 20 mm (3/4 inch) diameter rungs at 300 mm (12 inches) on center. Provide slide supports to allow for tank movement.
- J. Wear (Striker) Plates: Provide 300 mm (12 inch) square, 6 mm (1/4 inch) thick steel plates welded to tank bottom directly under the sounding opening, the fuel return discharge, and the fill discharge.
- K. Lifting Lugs: Provide for rigging tanks.
- L. Emergency Relief Vents for Fire Exposure: Venting capacity shall conform to NFPA 30 or NFPA 31 as applicable. Standard product of a manufacturer, designed to automatically open at tank pressure of 17 kPa (2.5 psig) gauge. Aluminum or cast-iron construction with Teflon seating surface. Provide separate vents for primary and secondary tanks.
- M. Provide fittings for grounding per NFPA 70.

2.3 ABOVEGROUND CONCRETE-INSULATED STEEL VAULT TANKS (NOT USED)

2.4 UNDERGROUND FIBERGLASS REINFORCED PLASTIC TANKS (NOT USED)

2.5 SOIL SEPARATOR MAT

- A. Material: Porous, non-woven polypropylene geotextile, Weight: 135 g per sq. meter (4 ounces per square yard), resistant to all alkalies and weak acids.

2.6 TANK AND PIPING ACCESSORIES

- A. Vent Caps: Galvanized cast iron or cast aluminum with brass or bronze screens, arranged to permit full venting and to prevent entry of foreign material into the vent line. Same pipe size as vent pipe.
- B. Fill Boxes:
1. Spill-container type enclosing a fill cap assembly with camlock hose connector with closure coordinated with fittings used by fuel supplier.
 2. Watertight assembly, cylindrical body, quick-opening corrosion-resistant watertight sealable cover, polyethylene spill containment compartment with minimum 5 gallon capacity. Integral drain valve with discharge to fill pipe.
 3. Fill cap shall be lockable, tight-fill design with provision for padlock on the top of the cap. Fill cap shall screw onto threaded adapter that can be removed without removing fill box. Entire assembly shall seal tight with no leakage during filling and when cap is in place.
 4. Provide special tools necessary for opening fill boxes and fill caps.
 5. Protect spill container from traffic by ramped, drain-slotted cast iron body ring and cover. Design shall prevent transmission of traffic loads to the underground tank. Spill-container type not required at locations designated only for sounding tanks.
- C. Fill caps located above grade without fill boxes shall be lockable, tight-fill design, operated by special wrench that shall be furnished. Entire assembly shall seal tight with no leakage during fill and when cap is in place.
- D. Refer to Section 05 50 00, METAL FABRICATIONS, for access platforms shown for aboveground tanks.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

04-01-20

- E. Support horizontal portion of pipes located inside tank every 2100 mm (7 feet) maximum.
- F. Furnish gauging chart, liters versus mm and gallons versus inches depth.
- G. Furnish sounding rod for each tank size. Mark rods in increments representing five percent of tank capacity. Provide length of rod suitable for tank burial depth (if applicable). Rods shall be graduated in gallons.
- H. Fill Point Identification:
 - 1. Fill Boxes at Grade Level: Aluminum, brass or bronze plate, anchored to concrete fill box pad with stamped or engraved letters 20 mm (3/4 inch) high.
 - 2. Fill Caps above Grade: Aluminum, brass or bronze plate, clamped to fill pipe, with stamped or engraved letters 20 mm (3/4 inch) high.
 - 3. Legend: "BURNER FUEL OIL FILL" "DIESEL FUEL FILL" or "SOUNDING" as appropriate.

2.7 PIPING, VALVES, FITTINGS

- A. Fuel supply and return, tank fill, vents, sounding, and pump out.
- B. Steel Pipe and Fittings:
 - 1. Piping: Steel, seamless or electric resistance welded (ERW), ASTM A53/A53M Grade B or ASTM A106/A106M Grade B, Schedule 40.
Aboveground piping shall be painted. Refer to Section 09 91 00, PAINTING.
 - 2. Joints: Socket or butt-welded. Threaded joints are prohibited except at valves, unions and tank connections.
 - 3. Fittings:
 - a. Butt-welded joints: Steel, ASTM A234/A234M, Grade B, ASME B16.9, same schedule as adjoining pipe.
 - b. Socket-welded joints: Forged steel, ASME B16.11, 13,790 kPa (2000 psig) class.
 - 4. Unions: Malleable iron, 2070 kPa (300 psig) class.
 - 5. Companion flanges: Flanges and bolting, ASME B16.5.
 - 6. Welding flanges: Weld neck, ASME B16.5, forged steel ASTM A105/A105M, 1034 kPa (150 psig).

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

04-01-20

C. Glass Fiber Reinforced Plastic (FRP) Pipe and Fittings:

1. Conform to UL 971 and ASTM D2996 using a filament-winding process and epoxy or vinyl ester resins.
2. Design pipe, fittings and joining system for required fuel service, 65 degrees C (150 degrees F), 1034 kPa (150 psig) pressure, 68 kPa (20 inches Hg) vacuum.
3. Provide an integral resin-rich liner, 0.5 mm (0.020 inches) minimum thickness to enhance the corrosion resistance. Outer layer shall include ultra-violet inhibitors. Joining adhesive shall be designed for the pipe furnished and shall be supplied by the pipe manufacturer.
4. Plastic piping allowed in underground use only.

D. Check Valves - Fuel Pump Suction.

1. Pipe Sizes 50 mm (2 inches) and under: Rated for 1375 kPa (200 psig) water-oil-gas, swing-type, threaded ends, ASTM B62 bronze body. Provide union adjacent to valve.
2. Pipe Sizes 65 mm (2-1/2 inches) and above: Rated for 1380 kPa (200 psig) water-oil-gas, swing-type, 861 kPa (125 pounds) ASME flanged ends, ASTM A126 class B cast iron body.

E. Foot Valves - Fuel Pump Suction: Double poppet, lapped-in metal-to-metal seats, double-guided stems, 20 mesh inlet screen, same size as fuel suction piping. Foot valve shall be removable to above grade through the tank manhole enclosure or through extractor fitting.

F. Extractor Fittings: Arranged to permit removal of foot valves, overflow prevention valves, and other devices that are located below grade. Access point shall be through a cast iron fill box-type manhole located at grade. Provide extractor wrench.

G. Overflow Prevention Valve: Aluminum automatic valve designed for underground or aboveground tanks, as applicable. Removable through the extractor fitting on underground tanks. Locate valve near the top of the tank in the fill pipe. On underground tanks with gravity fill, provide two stage automatic float-operated valve. First stage operation at 92 percent tank capacity shall reduce flow to 0.3 L/s (5 gpm) or less. Second stage operation shall stop flow completely when tank is no more than 95 percent full. On aboveground tanks, or tanks pressure-filled, provide single stage valve, rated for fill flow and pressure,

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

04-01-20

which stops flow completely at 95 percent of tank capacity. Valve shall include method for draining oil trapped above the valve into the tank.

2.8 SECONDARY CONTAINMENT FOR UNDERGROUND FUEL PIPING SYSTEMS (NOT USED)

2.9 LEAK DETECTION SYSTEMS

A. Automatic digital continuous monitoring systems responsive to the presence of water and hydrocarbons in the interstitial space of the double-wall tanks, in the tank manhole access enclosures, and in the secondary containment of fuel piping systems. System shall distinguish between hydrocarbon and water and identify location of leak as to individual tank and piping system. System may be combined with tank fluid level monitor and alarm system specified in paragraph, TANK FLUID LEVEL MONITOR AND ALARM SYSTEM.

B. Functions and Arrangement:

1. Single control station to monitor all sensing probes.
2. Visual indicator to monitor and identify leaks as water or hydrocarbon and location.
3. Indicators showing system status including faults and alarms.
4. On board printer that provides complete reports of all system functions upon command.
5. Panel circuit test button.
6. 95 dB audible alarm with silencing control to sound when leak is detected.
7. Eight-hour memory backup system with battery.
8. NEMA 250 Type 4 cabinet.
9. UL or other accredited testing laboratory listing.

C. Sensors:

1. Designed for required locations including: Insertion between walls of double-wall tanks, in sumps in double-wall piping systems and in tank manhole enclosures. Sensing points shall be at lowest point of each tank or sump. Intrinsically safe design.
2. Sensing units shall detect presence of water and a minimum 3.2 mm (1/8 inch) thick layer of hydrocarbon on surface of water and minimum 50 mm (2 inch) thickness of hydrocarbon in area that has no water present.
3. Sensors shall be arranged to allow replacement of individual sensors without disturbing other portions of leak detection system or fuel

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

04-01-20

storage and piping system. Underground sensors shall be accessed through caps as grade.

4. Materials of construction shall be non-corroding.
5. Transmit status signal to control unit.

D. Components:

1. Provide manholes at grade for each sensor cap similar in construction to fill boxes. Manholes shall be cast iron, quick-opening cover, watertight, minimum size necessary to accommodate sensor caps. Provide identification plates, similar to those specified for fill points, labeled "MONITORING/OBSERVATION WELL-DO NOT FILL". Provide special tools if necessary for opening covers.
2. Sensor housings from tank and piping to grade shall be Schedule 40 PVC, or stainless steel.
3. Underground wiring between probes and control unit: Place in water-tight corrosion-resistant conduit system conforming to Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION.

2.10 TANK FLUID LEVEL MONITOR AND ALARM SYSTEMS

A. Digital systems for central monitoring of fuel and water levels in all fuel oil storage tanks in the project. High and low level visual and audible alarms. Volumetric tank-tightness testing. Complete with all transducing, transmitting, and receiving devices. On board printer to provide complete report of all system functions upon command. System may be combined with leak detection system specified in paragraph, LEAK DETECTION SYSTEMS.

B. Fluid Level Monitor:

1. Digital continuous readout, showing tank oil and water levels in gallons, smallest reading one gallon. Provide identification of product measured, measuring units, and the tank number.
2. Tank and fuel characteristics contained in preprogrammed non-volatile field-replaceable databases. Protected power supply.

C. High and Low Fluid Level Alarm System:

1. Automatic continuous on-line monitoring of all tanks.
2. Visual and audible indicators combined with fluid level monitor. Identify the tank that is in alarm condition.
3. Manual alarm test and silencing controls.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

04-01-20

4. Low level alarm actuation adjustable 0-25 percent of tank capacity.
High level alarm actuation adjustable 75-100 percent of tank capacity.
- D. Locate all indicators, selector switches, alarms on face of wall-mounted NEMA 250, Type 4 panel.
- E. Remote Alarm Annunciator:
 1. Visual and audible high-level alarms adjacent to tank fill box locations. Locate in NEMA 250 Type 4X weatherproof exterior wall or pole-mounted panels.
 2. Alarm shall include flashing red light with 180-degree visibility for each tank and 95 dB horn or 100 mm (4 inch) diameter bell. Provide alarm silence control.
 3. Provide identification sign: "WHEN ALARM SOUNDS - FUEL TANK FILLED TO CAPACITY - DO NOT OVERFILL".
- F. Modbus communication to engineering control system to indicate tank fluid level and alarm conditions. Telephone modem communication capability.
- G. System Performance: Accuracy plus or minus 2.5 mm (0.10 inch) of fluid height in inventory mode and 0.25 mm (0.01 inch) in leak detection mode. Automatic compensation for fluid temperature changes. Volumetric tank tightness sensitivity of 0.4 lph (0.1 gph).
- H. Sensors:
 1. Provide sensor types such as magnetostrictive, capacitance, float, hydrostatic and other types as necessary for the applications.
 2. Apply in accordance with manufacturer's instructions with provisions for easy future replacement without need for excavation.
 3. Provide for each hydrostatic sensor a constant flow differential pressure regulator and transmitter protected from fuel contamination. Air supply shall include filter and over-pressure protection. Provide desiccant-type dryer on air supply designed for removal of water vapor. Dryer rating, minimum 4.6 L/s (10 SCFM). Provide moisture indicator. Dryer may be deleted if air supply source has a refrigerated dryer.
 4. Float-type units shall be designed for installation and removal through a 100 mm (4 inch) diameter vertical pipe mounted in the top of the tank.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

04-01-20

I. Underground Wiring and Piping: Enclose in water-tight corrosion-resistant conduit system sized and arranged as recommended by system manufacturer and conforming to Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION.

J. Code Conformance: NFPA 70.

2.11 FUEL OIL QUALITY MAINTENANCE SYSTEMS

A. Complete factory-assembled automatic particulate filtration and dewatering system to maintain the purity of No. 2 fuel oil in storage. The system shall circulate the oil from the storage tank, through the system, and back to the storage tank. Provide quantity and capacity of systems to serve tanks as shown, connected to the tank suction and return pipes. Drawings may show multiple tanks served by one system. Smaller systems without large water storage tanks and without fuel additive injection shall be wall-mounted. Units with water storage tanks and/or additive injection shall be floor-mounted on steel skids on concrete foundations. Digital controls.

B. Performance: Design for nearly 100 percent water removal. Provide 2-micron particulate filtration. Each system shall have capacity to turn over the largest connected full tank one time within 22 hours maximum. System shall be designed to allow continuous operation with brief interruptions to manually change filters and clean strainers.

C. Components:

1. Strainer: 100 mesh perforated stainless steel basket. Clamped covers. 861 kPa (125 psig) design pressure.
2. Water Separation Unit: Two stage, designed to reduce water content of fuel to less than 10 ppm. Centrifugal separator for removal of large droplets and renewable resin-impregnated cellulose water coalescing elements. Water removed shall flow to water holding sump in the unit. Water sensing probe to alert the operator when water level in bowl has reached capacity. Automatic pumped drain to holding tank actuated by electronic water level sensing devices in the separation unit.
3. Filter: 2-micron filtration with 96 percent removal efficiency, valved manual drain. Replaceable elements.
4. Filtration Pump: Positive displacement base-mounted pump with cast iron or bronze housing, for circulating the oil from the storage

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

04-01-20

tank, through the water separation and filter units and back to the storage tank. Pump shall have carbon bushings, stainless steel shaft and Teflon mechanical seal, ODP motor.

5. Controls:

- a. Digital PLC electronic controls for all system control and alarm functions. Relay logic not acceptable.
- b. Control panel with selector for modes of operation, indicators to show system status, and visual and audible alarms to signal the need for operator intervention. Operator interface shall be 2 x 20 LCD and keypad.
- c. Controls shall include:
 - 1) Control power "on-off".
 - 2) "Cycle Start".
 - 3) "Cycle Cancel".
 - 4) "Hand-off-Auto" for filtration pump.
 - 5) Pump cycle timer set function.
 - 6) Cycle duration selector.
- d. Indications shall include:
 - 1) "Control Power On".
 - 2) "Pump Run".
 - 3) "Pump Failure".
 - 4) "Excess Water in Fuel".
 - 5) "Filter Water Level High".
 - 6) "Rupture Basin Leak" alarm.
 - 7) "High Pressure Drop in Strainer" alarm.
 - 8) "High Pressure Drop in Filters" alarm.
 - 9) "High Pressure" alarm and automatic shutdown.
 - 10) "High Water Level" in water storage tank.
- e. Filter and strainer differential pressure gauges, differential pressure switches and control. Provide indication when filters should be changed.
- f. Over pressure switch and control to shut down pump if filter inlet pressure exceeds limits.
- g. All primary wiring exiting the enclosure shall be encased in conduit.
- h. Magnetic motor starters with overload protection.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

04-01-20

- i. Circuit breakers.
 - j. Control enclosure shall be NEMA 4, fully gasketed doors with 3 point lockable latching. Interior shall have white gloss finish; exterior shall be chemical-resistant gray enamel. All controls and indicating devices shall be mounted on front of enclosure and labeled with black Phenolic labels with white lettering.
 - k. Modbus communication to engineering control system for alarms and system status.
- D. Enclosure - Wall Mounted Units: 14-gauge steel, NEMA Type 4 enclosure, continuously welded, framed cabinet. Provide doors for complete access to all equipment. Doors shall have a turned edge, piano hinges, three-point locking mechanisms. Corrosion-resistant prime and finish coatings on all interior and exterior surfaces.
- E. Piping: Refer to Section 23 21 11, BOILER PLANT PIPING SYSTEMS.
- F. Pressure Gauges: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

2.12 CONCRETE FOUNDATIONS

- A. Concrete ballast foundations for underground tanks and concrete pads for aboveground tanks are specified under Section 03 30 00, CAST-IN-PLACE CONCRETE. Ballast foundations shall be sized for buoyancy of entire tank when empty. Credit for overburden is allowed.

2.13 BURIED UTILITY WARNING TRACING TAPE

- A. Tape shall be 0.1 mm (0.004 inch) thick, 150 mm (6 inches) wide, yellow polyethylene with a metallic core, acid and alkali-resistant and shall have a minimum strength of 12,000 kPa (1740 psig) lengthwise and 10,342 kPa (1500 psig) crosswise with an elongation factor of 350 percent. Provide bold black letters on the tape identifying the type of system. Insulating and labeling shall be unaffected by moisture and other substances contained in the backfill material.

PART 3 - EXECUTION

3.1 GENERAL

- A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

3.2 INSTALLATION AND TESTING, ABOVEGROUND TANKS

- A. Conform to NFPA 30 or NFPA 31 as applicable.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

04-01-20

- B. Support tanks on steel saddles welded to the tanks. Anchor to concrete foundations. Provide molded neoprene isolation pads between the steel supports and the concrete foundation.
- C. After tanks are installed, test steel tanks with air pressure of 21 kPa to 34 kPa (3 to 5 psig), using soapsuds to locate leaks. Repair leaks by chipping to bare metal and rewelding. Retest until all leaks are repaired. Repair all damaged areas of prime coat on tanks and steel dikes (if furnished). Test interstitial area between steel tank walls with air at pressure recommended by tank manufacturer. Tests shall be witnessed by the COR.
- D. For steel tanks storing heated oil, field-applied insulation requirements are specified under Section 23 07 11, HVAC AND BOILER PLANT INSULATION.
- E. Surface finish coating for tanks and steel dikes (if furnished) is specified under Section 09 91 00, PAINTING.
- F. Provide electrical grounding in accordance with NFPA 70.

3.3 INSTALLATION AND TESTING, UNDERGROUND FIBERGLASS REINFORCED PLASTIC TANKS (NOT USED)

3.4 INSTALLATION AND TESTING, UNDERGROUND PIPING SYSTEMS

- A. Leak Detection System: Arrange fuel and tracing media (if required for heated oil) carrier piping, enclosed in secondary containment piping, to accommodate leak detection system. Slope piping down toward tanks and leak detectors at 25 mm in 12 m (1 inch in 40 feet).
- B. Steel Fuel and Tracing Media Carrier Piping: All joints butt or socket welding. Threaded piping is prohibited. Piping ends shall be accurately cut, true, and beveled for welding.
- C. Glass Fiber Reinforced Plastic (FRP) Fuel Carrier Piping and Secondary Containment Piping: Install in accordance with printed instructions of pipe manufacturer. Installation personnel trained in accordance with paragraph, QUALITY ASSURANCE. Plastic piping is prohibited in the same secondary containment system with steam or condensate piping.
- D. Secondary Containment Piping:
 - 1. Provide sand bedding and backfill material for steel piping and pea gravel for FRP piping.
 - 2. Top of system 450 mm (18 inches) minimum below grade.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

04-01-20

3. Design and locate leak detector sumps to intercept all potential leakage. Maximum spacing along each system, 3000 mm (10 feet).
4. Seal all building and manhole wall penetrations with a modular, watertight flexible penetration seal system. The modular penetration seal shall have a nitrile rubber seal, or if a fire separation is required, a high temperature silicone fire seal.
5. After placing system, prior to backfill, repair all damage, including coatings, as recommended in printed instructions of system manufacturer. Perform 10,000-volt holiday test on coated steel systems.
6. Fuel oil piping is prohibited in the same secondary containment system as steam or condensate piping.
7. On steel systems that do not have FRP cladding, install cathodic protection system.
- E. Anchorage of System: When heated oil system is provided, anchor systems and provide expansion loops and bends as shown and as recommended by manufacturer of system. Pipe stress due to thermal expansion shall not exceed the limits in ASME B31.1.
- F. Leak Test: Test carrier pipes with air pressure at 690 kPa (100 psig), and test the containment piping with air pressure at 55 kPa (8 psig). Systems shall hold the pressure for 30 minutes. Repair all leaks and retest.
- G. Coatings for Steel Piping not in Secondary Containment System: Provide urethane coating and cathodic protection.

3.5 INSTALLATION, FILL BOXES AND ACCESS MANHOLES AT GRADE

- A. Provide for tank fill, tank sounding, leak detector sensors, and extractor fittings. Set at grade in concrete pads. Refer to fill box detail. Provide identification plate set into the concrete pad that identifies the purpose of the device and type of fuel in the tank.

3.6 INSTALLATION AND TESTING, LEAK DETECTOR SYSTEMS FOR TANKS AND PIPING

- A. Wiring shall conform to NFPA 70.
- B. Locate control monitor panels 1500 mm (5 feet) above the floor on inside wall of boiler room, generator room or garage, depending on type of fuel tank served, unless shown otherwise.

- C. Test operation of each probe, and monitoring system with fuel and water. If type of probe utilized is damaged by exposure to fuel, provide temporary probe for testing monitoring system.

3.7 INSTALLATION, TANK FLUID LEVEL INDICATOR AND ALARM SYSTEM

- A. Wiring shall conform to NFPA 70.
- B. Locate level indicator and alarm panel 1500 mm (5 feet) above the floor on inside wall of boiler room, generator room or garage, depending on type of fuel tank served, unless shown otherwise.
- C. Locate remote high-level alarm on exterior wall or pole in view of tank fill point, 2400 mm (8 feet) above grade.

3.8 INSTALLATION, BURIED UTILITY WARNING TRACING TAPE

- A. Install tracer wire in the trench approximately 457 mm (18 inches) above the non-metallic pipe. The tracer wire shall be taped approximately every 3 m (10 feet) to the pipe, where practical. The tracer wire shall be installed so that electrical continuity is maintained throughout the pipe system. As few connections as possible shall be made in the tracer wire. The wire shall be contiguous except at test stations, valve boxes, and where splicing is required. All splices shall be encased. Connections will be made by stripping the insulation back one inch and joining the two ends using an approved mechanical connector and a split bolt connector. Twisting of copper wire is prohibited. To complete this connection, wrap all exposed wire thoroughly with electrical tape. A minimum 1.5 m (5 foot) of additional tracer wire will be coiled, buried and terminate aboveground at the ends of the pipeline.

3.9 INSTALLATION, FUEL OIL QUALITY MAINTENANCE SYSTEMS

- A. Locate systems within easy reach of persons standing on floor, with sufficient elevation to allow gravity flow of water from system to water storage tank sitting on the floor.
- B. Connect to tank suction and return piping systems with isolation valves. Provide compound pressure gauges at suction and discharge piping connections. Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT for gauge requirements.

3.10 TANK MANHOLE ENCLOSURES

- A. All pipe penetrations shall be leak tight permitting no groundwater into enclosure.

3.11 STARTUP AND TESTING

- A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.
- B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.
- C. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.

3.12 INSTALLATION, CATHODIC PROTECTION TEST STATIONS

- A. Provide separate station for each tank and each piping system, anchor firmly, locate so that terminal board is 600 mm (2 feet) minimum above grade. Connect wiring from all anodes and protected structures to the test stations.

3.13 TESTING, CATHODIC PROTECTION

- A. Testing performed by NACE-certified corrosion specialist; witnessed by COR.
- B. Test Instruments:
 - 1. Volt-Ammeter.
 - 2. Saturated copper-copper sulfate reference electrode.
 - 3. Other instruments as required.
- C. Procedures: Conform to NACE SP0169.
- D. Test Results Required for Acceptance:
 - 1. Potential of minus 0.85 volt between protected structure and reference electrode.
 - 2. Minimum shift of minus 300 millivolts upon application of protective current. Voltage measured between protected structure and reference electrode.
 - 3. Minimum shift of minus 100 millivolts upon interruption of protective current. Voltage measured between protected structure and reference electrode.
- E. Test Report: Provide complete report to COR showing all test measurements, calculations, list of instruments used.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

04-01-20

3.14 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- B. Components provided under this section of the specification will be tested as part of a larger system.

3.15 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

- - - E N D - - -

SECTION 23 23 00
REFRIGERANT PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Field refrigerant piping for direct expansion HVAC systems. Field refrigerant piping and associated drain and condenser water piping for laboratory refrigerators, including required pipe insulation.
- B. Refrigerant piping shall be sized, selected, and designed either by the equipment manufacturer or in strict accordance with the manufacturer's published instructions. The schematic piping diagram shall show all accessories such as, stop valves, level indicators, liquid receivers, oil separator, gauges, thermostatic expansion valves, solenoid valves, moisture separators and driers to make a complete installation.
- C. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. Definitions:
 - 1. Refrigerating system: Combination of interconnected refrigerant-containing parts constituting one closed refrigeration circuit in which a refrigerant is circulated for the purpose of extracting heat.
 - a. Low side means the parts of a refrigerating system subjected to evaporator pressure.
 - b. High side means the parts of a refrigerating system subjected to condenser pressure.
 - 2. Brazed joint: A gas-tight joint obtained by the joining of metal parts with alloys which melt at temperatures higher than 449 degrees C (840 degrees F) but less than the melting temperatures of the joined parts.

1.2 RELATED WORK

- A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. Section 23 07 11, HVAC, and BOILER PLANT INSULATION.
- E. Section 23 81 00, DECENTRALIZED UNITARY HVAC EQUIPMENT
- F. Section 23 81 23, COMPUTER-ROOM AIR-CONDITIONERS

1.3 APPLICABLE PUBLICATIONS

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standards will govern.
- B. Air Conditioning, Heating, and Refrigeration Institute (ARI/AHRI):
- 495-2005.....Standard for Refrigerant Liquid Receivers
 - 730-2013.....Flow Capacity Rating of Suction-Line Filters and Suction-Line Filter-Driers
 - 750-2016.....Thermostatic Refrigerant Expansion Valves
 - 760-2014.....Performance Rating of Solenoid Valves for Use with Volatile Refrigerants
- C. American Society of Heating Refrigerating and Air Conditioning Engineers (ASHRAE):
- 15-2019.....Safety Standard for Refrigeration Systems (ANSI)
 - 17-2015.....Method of Testing Capacity of Thermostatic Refrigerant Expansion Valves (ANSI)
 - 63.2-2017.....Method of Testing Liquid Line Filter Drier Filtration Capability (ANSI)
- D. American National Standards Institute (ANSI):
- A13.1-2020.....Scheme for Identification of Piping Systems
 - Z535.1-2017.....Safety Color Code
- E. American Society of Mechanical Engineers (ASME):
- B16.22-2018.....Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings (ANSI)
 - B16.24-20016.....Cast Copper Alloy Pipe Flanges and Flanged Fittings, Class 150, 300, 400, 600, 900, 1500 and 2500 (ANSI)
 - B31.5-2019 Refrigeration Piping and Heat Transfer Components (ANSI)
 - B40.100-2013.....Pressure Gauges and Gauge Attachments
 - B40.200-2008.....Thermometers, Direct Reading and Remote Reading
- F. American Society for Testing and Materials (ASTM)
- A126-2014.....Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
 - B32-2020.....Standard Specification for Solder Metal

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

B88-2020.....Standard Specification for Seamless Copper
Water Tube

B88M-2020.....Standard Specification for Seamless Copper
Water Tube (Metric)

B280-2020.....Standard Specification for Seamless Copper Tube
for Air Conditioning and Refrigeration Field
Service

G. American Welding Society, Inc. (AWS): Brazing Handbook

A5.8/A5.8M-2019.....Standard Specification for Filler Metals for
Brazing and Braze Welding

H. Underwriters Laboratories (UL):

207-2009.....Standard for Refrigerant-Containing Components
and Accessories, Nonelectrical

429-2013.....Standard for Electrically Operated Valves

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in
accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND
SAMPLES.

B. Information and material submitted under this section shall be marked
"SUBMITTED UNDER SECTION 23 23 00, REFRIGERAN PIPING", with applicable
paragraph identification.

C. Shop Drawings:

1. Complete information for components noted, including valves and
refrigerant piping accessories, clearly presented, shall be included
to determine compliance with in the contract documents for
components noted below:

- a. Tubing and fittings
- b. Valves
- c. Strainers
- d. Moisture-liquid indicators
- e. Filter-driers
- f. Flexible metal hose
- g. Liquid-suction interchanges
- h. Oil separators (when specified)
- i. Gauges
- j. Pipe and equipment supports

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- k. Refrigerant and oil
- l. Pipe/conduit roof penetration cover
- m. Soldering and brazing materials
- 2. Layout of refrigerant piping and accessories, including flow capacities, valves locations, and oil traps slopes of horizontal runs, floor/wall penetrations, and equipment connection details.
- D. Certification: Copies of certificates for welding procedure, performance qualification record and list of welders' names and symbols.
- E. Design Manual: Furnish two copies of design manual of refrigerant valves and accessories.

1.5 QUALITY ASSURANCE

- A. Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Comply with ASHRAE Standard 15, Safety Code for Mechanical Refrigeration. The application of this Code is intended to assure the safe design, construction, installation, operation, and inspection of every refrigerating system employing a fluid which normally is vaporized and liquefied in its refrigerating cycle.
- C. Comply with ASME B31.5: Refrigerant Piping and Heat Transfer Components.
- D. Products shall comply with UL 207 "Refrigerant-Containing Components and Accessories, "Nonelectrical"; or UL 429 "Electrical Operated Valves."

1.6 AS-BUILT DOCUMENTATION

- A. Comply with requirements in Paragraph "AS-BUILT DOCUMENTATION" in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

PART 2 - PRODUCTS

2.1 PIPING AND FITTINGS

- A. Refrigerant Piping: For piping up to 100 mm (4 inch) use Copper refrigerant tube, ASTM B280, cleaned, dehydrated and sealed, marked ACR on hard temper straight lengths. Coils shall be tagged ASTM B280 by the manufacturer. For piping over 100 mm (4 inch) use A53 Black SML steel.
- B. Water and Drain Piping: Copper water tube, ASTM B88M, Type B or C (ASTM B88, Type M or L). Optional drain piping material: Schedule 80 flame retardant Polypropylene plastic.
- C. Fittings, Valves and Accessories:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

1. Copper fittings: Wrought copper fittings, ASME B16.22.
 - a. Braze Joints, refrigerant tubing: Cadmium free, AWS A5.8/A5.8M, 45 percent silver brazing alloy, Class BAg-5.
 - b. Solder Joints, water and drain: 95-5 tin-antimony, ASTM B32 (95TA).
2. Steel fittings: ASTM wrought steel fittings.
 - a. Refrigerant piping - Welded Joints.
3. Flanges and flanged fittings: ASME B16.24.
4. Refrigeration Valves:
 - a. Stop Valves: Brass or bronze alloy, packless, or packed type with gas tight cap, frost proof, back seating.
 - b. Pressure Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; UL listed. Forged brass with nonferrous, corrosion resistant internal working parts of high strength, cast iron bodies conforming to ASTM A126, Grade B. Set valves in accordance with ASHRAE Standard 15.
 - c. Solenoid Valves: Comply with ARI 760 and UL 429, UL-listed, two-position, direct acting or pilot-operated, moisture and vapor-proof type of corrosion resisting materials, designed for intended service, and solder-end connections. Fitted with suitable NEMA 250 enclosure of type required by location and normally open .
 - d. Thermostatic Expansion Valves: Comply with ARI 750. Brass body with stainless-steel or non-corrosive nonferrous internal parts, diaphragm and spring-loaded (direct-operated) type with sensing bulb and distributor having side connection for hot-gas bypass and external equalizer. Size and operating characteristics as recommended by manufacturer of evaporator and factory set for superheat requirements. Solder-end connections. Testing and rating in accordance with ASHRAE Standard 17.
 - e. Electronic Thermostatic Expansion Valves: Electronic thermal expansion valves shall be stepper motor high resolution drive assembly type for precision control. Valve shall not exceed 6 watts max consumption. Compatibility tested with most CFC, HCFC, and HFC refrigerants and oils. Valve pistons and ports to be characterized to provide improved flow resolution and

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

performance. Valves to be interfaced with microprocessor-based controllers by devise manufacturer with temperature feedback loop. Electric expansion valves to be sized with nominal steps of stroke for tonnage application as recommended by valve manufacture ranging from 500 steps on small tonnage (under 5 tons per circuit) to 6300 on large tonnage circuits (over 100 tons per circuit)

- f. Check Valves: Brass or bronze alloy with swing or lift type, with tight closing resilient seals for silent operation; designed for low pressure drop, and with solder-end connections. Direction of flow shall be legibly and permanently indicated on the valve body.
5. Strainers: Designed to permit removing screen without removing strainer from piping system, and provided with screens 80 to 100 mesh in liquid lines DN 25 (NPS 1) and smaller, 60 mesh in liquid lines greater than DN 25 (NPS 1), and 40 mesh in suction lines. Provide strainers in liquid line serving each thermostatic expansion valve, and in suction line serving each refrigerant compressor not equipped with integral strainer.
6. Refrigerant Moisture/Liquid Indicators: Double-ported type having heavy sight glasses sealed into forged bronze body and incorporating means of indicating refrigerant charge and moisture indication. Provide screwed brass seal caps.
7. Refrigerant Filter-Dryers: UL listed, angle or in-line type, as shown in the contract documents. Conform to ARI Standard 730. Heavy gauge steel shell protected with corrosion-resistant paint; perforated baffle plates to prevent desiccant bypass. Size as recommended by manufacturer for service and capacity of system with connection not less than the line size in which installed. Filter driers with replaceable filters shall be furnished with one spare element of each type and size.
8. Flexible Metal Hose: Seamless bronze corrugated hose, covered with bronze wire braid, with standard copper tube ends. Provide in suction and discharge piping of each compressor.

2.2 GAUGES

- A. Temperature Gauges: Comply with ASME B40.200. Industrial-duty type and in required temperature range for service in which installed. Gauges shall have Celsius scale in 1-degree (Fahrenheit scale in 2-degree) graduations and with black number on a white face. The pointer shall be adjustable. Rigid stem type temperature gauges shall be provided in thermal wells located within 1525 mm (5 feet) of the finished floor. Universal adjustable angle type or remote element type temperature gauges shall be provided in thermal wells located 1525 to 2135 mm (5 to 7 feet) above the finished floor. Remote element type temperature gauges shall be provided in thermal wells located 2135 mm (7 feet) above the finished floor.
- B. Vacuum and Pressure Gauges: Comply with ASME B40.100 and provide with throttling type needle valve or a pulsation dampener and shut-off valve. Gauge shall be a minimum of 90 mm (3-1/2 inches) in diameter with a range from 0 kPa (0 psig) to approximately 1.5 times the maximum system working pressure. Each gauge range shall be selected so that at normal operating pressure, the needle is within the middle-third of the range.
1. Suction: 101 kPa (30 inches Hg) vacuum to 1723 kPa (gauge) (250 psig).
 2. Discharge: 0 to 3445 kPa (gauge) (0 to 500 psig).

2.3 THERMOMETERS AND WELLS

- A. Refer to specification Section 23 21 13, HYDRONIC PIPING.

2.4 PIPE SUPPORTS

- A. Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.5 ELECTRICAL HEAT TRACING SYSTEM (NOT USED)

2.6 REFRIGERANTS AND OIL

- A. Provide EPA approved refrigerant and oil for proper system operation.

2.7 PIPE/CONDUIT ROOF PENETRATION COVER

- A. Prefabricated Roof Curb: Galvanized steel or extruded aluminum 300 mm (12 inches) overall height, continuous welded corner seams, treated wood nailer, 38 mm (1-1/2 inch) thick, 48 kg/cubic meter (3 pounds/cubic foot) density rigid mineral fiberboard insulation with metal liner, built-in cant strip (except for gypsum or tectum decks).
For surface insulated roof deck, provide raised cant strip (recessed

03-01-23

mounting flange) to start at the upper surface of the insulation. Curbs shall be constructed for pitched roof or ridge mounting as required to keep top of curb level.

- B. Penetration Cover: Galvanized sheet metal with flanged removable top. Provide 38 mm (1-1/2 inch) thick mineral fiber board insulation.
- C. Flashing Sleeves: Provide sheet metal sleeves for conduit and pipe penetrations of the penetration cover. Seal watertight penetrations.

2.8 PIPE INSULATION FOR DX HVAC SYSTEMS

- A. Refer to specification Section 23 07 11, HVAC, PLUMBING, and BOILER PLANT INSULATION.

2.9 PIPE INSULATION FOR WALK-IN COOLERS AND FREEZERS AND LABORATORY REFRIGERATORS AND MORTUARY REFRIGERATORS

- A. Flexible elastomeric: Refer to specification Section 23 07 11, HVAC, PLUMBING, and BOILER PLANT INSULATION.
- B. Insulate refrigerant suction piping from unit cooler to condensing unit. Use 20 mm (3/4-inch) thick insulation on piping inside the refrigerator or freezer and 40 mm (1-1/2 inch) thick insulation (double layer required) on piping outside the refrigerated space.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install refrigerant piping and refrigerant containing parts in accordance with ASHRAE Standard 15 and ASME B31.5
 - 1. Install piping as short as possible, with a minimum number of joints, elbow and fittings.
 - 2. Install piping with adequate clearance between pipe and adjacent walls and hangers to allow for service and inspection. Space piping, including insulation, to provide 25 mm (1 inch) minimum clearance between adjacent piping or other surface. Use pipe sleeves through walls, floors, and ceilings, sized to permit installation of pipes with full thickness insulation.
 - 3. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown in the contract documents.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

4. Use copper tubing in protective conduit when installed below ground.
5. Install hangers and supports per ASME B31.5 and the refrigerant piping manufacturer's recommendations.

B. Joint Construction:

1. Brazed Joints: Comply with AWS "Brazing Handbook" and with filler materials complying with AWS A5.8/A5.8M.
 - a. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper tubing.
 - b. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.
 - c. Swab fittings and valves with manufacturer's recommended cleaning fluid to remove oil and other compounds prior to installation.
 - d. Pass nitrogen gas through the pipe or tubing to prevent oxidation as each joint is brazed. Cap the system with a reusable plug after each brazing operation to retain the nitrogen and prevent entrance of air and moisture.

C. Protect refrigerant system during construction against entrance of foreign matter, dirt and moisture; have open ends of piping and connections to compressors, condensers, evaporators and other equipment tightly capped until assembly.

D. Pipe relief valve discharge to outdoors for systems containing greater than 45 kg (100 lbs) of refrigerant.

E. Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11, HVAC, and BOILER PLANT INSULATION.

F. If in the substantiated evaluation of the COR, the installation fails to meet the requirements of the construction documents with respect to function and maintainability, an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

3.2 PIPE AND TUBING INSULATION

A. Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Apply two coats of weather-resistant finish as recommended by the manufacturer to insulation exposed to outdoor weather.

3.3 SIGNS AND IDENTIFICATION

- A. Each refrigerating system erected on the premises shall be provided with an easily legible permanent sign securely attached and easily accessible, indicating thereon the name and address of the installer, the kind and total number of pounds of refrigerant required in the system for normal operations, and the field test pressure applied.
- B. Systems containing greater than 50 kg (110 lb) of refrigerant shall be provided with durable signs, in accordance with ANSI A13.1 and ANSI Z535.1, having letters not less than 13 mm (1/2 inch) in height designating:
 - 1. Valves and switches for controlling refrigerant flow, the ventilation and the refrigerant compressor(s).
 - 2. Signs on all exposed high pressure and low pressure piping installed outside the machinery room, with name of the refrigerant and the letters "HP" or "LP."

3.4 FIELD QUALITY CONTROL

- A. Prior to initial operation examine and inspect piping system for conformance to plans and specifications and ASME B31.5. Correct equipment, material, or work rejected because of defects or nonconformance with plans and specifications, and ANSI codes for pressure piping.
- B. After completion of piping installation and prior to initial operation, conduct test on piping system according to ASME B31.5. Furnish materials and equipment required for tests. Perform tests in the presence of COR. If the test fails, correct defects and perform the test again until it is satisfactorily done and all joints are proved tight.
 - 1. Every refrigerant-containing parts of the system that is erected on the premises, except compressors, condensers, evaporators, safety devices, pressure gauges, control mechanisms and systems that are factory tested, shall be tested and proved tight after complete installation, and before operation.
 - 2. The high and low side of each system shall be tested and proved tight at not less than the lower of the design pressure or the setting of the pressure-relief device protecting the high or low side of the system, respectively, except systems erected on the

03-01-23

premises using non-toxic and non-flammable Group A1 refrigerants with copper tubing not exceeding DN 18 (NPS 5/8). This may be tested by means of the refrigerant charged into the system at the saturated vapor pressure of the refrigerant at 20 degrees C (68 degrees F) minimum.

- C. Test Medium: A suitable dry gas such as nitrogen or shall be used for pressure testing. The means used to build up test pressure shall have either a pressure-limiting device or pressure-reducing device with a pressure-relief device and a gauge on the outlet side. The pressure relief device shall be set above the test pressure but low enough to prevent permanent deformation of the system components.

3.5 SYSTEM TEST AND CHARGING

- A. System Test and Charging: As recommended by the equipment manufacturer or as follows:
1. Connect a drum of refrigerant to charging connection and introduce enough refrigerant into system to raise the pressure to 70 kPa (10 psig) gauge. Close valves and disconnect refrigerant drum. Test system for leaks with halide test torch or other approved method suitable for the test gas used. Repair all leaking joints and retest.
 2. Connect a drum of dry nitrogen to charging valve and bring test pressure to design pressure for low side and for high side. Test entire system again for leaks.
 3. Evacuate the entire refrigerant system by the triplicate evacuation method with a vacuum pump equipped with an electronic gauge reading in mPa (microns). Pull the system down to 665 mPa (500 microns) 665 mPa (2245.6 inches of mercury at 60 degrees F) and hold for 8 hours then break the vacuum with dry nitrogen (or refrigerant). Repeat the evacuation two more times breaking the third vacuum with the refrigeration to be charged and charge with the proper volume of refrigerant.

3.6 STARTUP AND TESTING

- A. The CxA will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and CxA. Provide a minimum of 7 days prior notice.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- B. Provide services of manufacturer's technical representative for four hours to instruct VA personnel in operation and maintenance of computer room air conditioning equipment.

3.7 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the CxA.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.8 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for 4 hours to instruct VA personnel in operation and maintenance of units.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 31 00
HVAC DUCTS AND CASINGS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Ductwork and accessories for HVAC including the following:
 - 1. Supply air, return air, exhaust, and relief systems.
- C. Definitions:
 - 1. Seal or Sealing: Use of liquid or mastic sealant, with or without compatible tape overlay, or gasketing of flanged joints, to keep air leakage at duct joints, seams and connections to an acceptable minimum.
 - 2. Duct Pressure Classification: SMACNA HVAC Duct Construction Standards, Metal and Flexible.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.
- D. Section 07 84 00, FIRESTOPPING.
- E. Section 08 90 00, LOUVERS and VENTS.
- F. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- G. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- H. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.
- I. Section 23 07 11, HVAC and BOILER PLANT INSULATION.
- J. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- K. Section 23 34 00, HVAC FANS.
- L. Section 23 36 00, AIR TERMINAL UNITS.
- M. Section 23 82 00, CONVECTION HEATING and COOLING UNITS.
- N. Section 28 31 00, FIRE DETECTION and ALARM.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standards will govern.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
Bancroft Architects + Engineers

03-01-23

- B. American Society of Civil Engineers (ASCE):
- 7-2016.....Minimum Design Loads for Associated Criteria
for Buildings and Other Structures
- C. American Society for Testing and Materials (ASTM):
- A653/A653M-2020.....Standard Specification for Steel Sheet,
Zinc-Coated (Galvanized) or Zinc-Iron Alloy-
Coated (Galvannealed) by the Hot-Dip Process
- A1011/A1011-2018a.....Standard Specification for Steel, Sheet and
Strip, Hot-Rolled, Carbon, Structural, High-
Strength Low-Alloy, High Strength Low-Alloy
with Improved Formability, and Ultra-High
Strength
- B209-2021.....Standard Specification for Aluminum and
Aluminum-Alloy Sheet and Plate
- C1071-2019.....Standard Specification for Fibrous Glass Duct
Lining Insulation (Thermal and Sound Absorbing
Material)
- E1-2014 (R2020).....Standard Specification for ASTM Liquid-in-Glass
Thermometers
- E77-2014 (R2021).....Standard Test Method for Inspection and
Verification of Thermometers
- E84-2021a.....Standard Test Method for Surface Burning
Characteristics of Building Materials
- D. National Fire Protection Association (NFPA):
- 90A-2021.....Standard for the Installation of
Air-Conditioning and Ventilating Systems
- 96-2021.....Standard for Ventilation Control and Fire
Protection of Commercial Cooking Operations
- E. Sheet Metal and Air Conditioning Contractors National Association
(SMACNA):
- 006-2020.....HVAC Duct Construction Standards, Metal and
Flexible, 4th Edition
- 016-2012.....HVAC Air Duct Leakage Test Manual, 2nd Edition
- 2016.....Fibrous Glass Duct Construction Standards, 7th
Edition

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
Bancroft Architects + Engineers

03-01-23

F. Underwriters Laboratories, Inc. (UL):

181-2013(R2017).....Standard for Factory-Made Air Ducts and Air
Connectors

555-2006(R2020) Standard for Fire Dampers

555S-2014(R2020).....Standard for Smoke Dampers

G. Department of Veterans Affairs (VA):

PG-18-10-2015.....Physical Security Design Manual for VA Mission
Critical Facilities

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in
accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND
SAMPLES.

B. Information and material submitted under this section shall be marked
"SUBMITTED UNDER SECTION 23 XX XX, SECTION TITLE", with applicable
paragraph identification.

C. Manufacturer's Literature and Data Including: Full item description and
optional features and accessories. Include dimensions, weights,
materials, applications, standard compliance, model numbers, size, and
capacity.

1. Rectangular Ducts:

a. Schedules of duct systems, materials and selected SMACNA
construction alternatives for joints, sealing, gauge and
reinforcement.

b. Duct liner.

c. Sealants and gaskets.

d. Access doors.

2. Round and Flat Oval Ducts:

a. Manufacturer's details for duct fittings.

b. Sealants and gaskets.

c. Access sections.

d. Installation instructions.

3. Volume dampers, back draft dampers.

4. Upper hanger attachments.

5. Fire dampers, fire doors, and smoke dampers with installation
instructions.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

7. Flexible ducts and clamps, with manufacturer's installation instructions.
 8. Flexible connections.
 9. Instrument test fittings.
 10. Details and design analysis of alternate or optional duct systems.
- D. Coordination Drawings: Refer to paragraph SUBMITTALS in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- E. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replaceable parts, and troubleshooting guide:
1. Include complete list indicating all components of the systems.
 2. Include complete diagrams of the internal wiring for each item of equipment.
 3. Diagrams shall have their terminals identified to facilitate installation, operation, and maintenance.

1.5 QUALITY ASSURANCE

- A. Bio-Based Materials: For products designated by the USDA's Bio-Preferred Program, provide products that meet or exceed USDA recommendations for bio-based content, so long as products meet all performance requirements in this specifications section. For more information regarding the product categories covered by the Bio-Preferred Program, visit <http://www.biopreferred.gov>.
- B. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.
- C. Fire Safety Code: Comply with NFPA 90A.
- D. Duct System Construction and Installation: Referenced SMACNA Standards are the minimum acceptable quality.
- E. Duct Sealing, Air Leakage Criteria, and Air Leakage Tests: Ducts shall be sealed as per duct sealing requirements of SMACNA HVAC Air Duct Leakage Test Manual for duct pressure classes shown in the contract documents.
- F. Duct accessories exposed to the air stream, such as dampers of all types (except smoke dampers) and access openings, shall be of the same material as the duct or provide at least the same level of corrosion resistance.

1.6 AS-BUILT DOCUMENTATION

- A. Comply with requirements in paragraph AS-BUILT DOCUMENTATION of Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

PART 2 - PRODUCTS

2.1 DUCT MATERIALS AND SEALANTS

- A. General: Except for systems specified otherwise, construct ducts, casings, and accessories of galvanized sheet steel, ASTM A653/A653M, coating G90; or, aluminum sheet, ASTM B209, alloy 1100, 3003 or 5052.
- B. Specified Corrosion Resistant Systems: Stainless-steel sheet, Class 302 or 304, Condition A (annealed) Finish No. 4 for exposed ducts and Finish No. 2B for concealed duct or ducts located in mechanical rooms.
- C. Optional Duct Materials:
1. Grease Duct: Double wall factory-built grease duct, UL labeled and complying with NFPA 96 may be furnished in lieu of specified materials for kitchen and grill hood exhaust duct. Installation and accessories shall comply with the manufacturers catalog data. Outer jacket of exposed ductwork shall be stainless-steel. Square and rectangular duct shown in the contract documents will have to be converted to equivalent round size.
- D. Joint Sealing: Refer to SMACNA HVAC Duct Construction Standards, Metal and Flexible.
1. Sealant: Elastomeric compound, gun or brush grade, maximum 25 flame spread, and 50 smoke developed (dry state) compounded specifically for sealing ductwork as recommended by the manufacturer. Generally, provide liquid sealant, with or without compatible tape, for low clearance slip joints and heavy, permanently elastic, mastic type where clearances are larger. Oil base caulking and glazing compounds are prohibited because they do not retain elasticity and bond.
 2. Tape: Use only tape specifically designated by the sealant manufacturer and apply only over wet sealant. Pressure sensitive tape shall not be used on bare metal or on dry sealant.
 3. Gaskets in Flanged Joints: Soft neoprene.
- E. Approved factory-made joints may be used.

2.2 DUCT CONSTRUCTION AND INSTALLATION

- A. Regardless of the pressure classifications outlined in the SMACNA Standards, fabricate and seal the ductwork in accordance with the following pressure classifications:
- B. Duct Pressure Classification:
 - 1. 0 to 1/2 inch
 - 2. 1/2 inch to 1 inch
 - 3. 1 inch to 2 inch
 - 4. 2 inch to 3 inch
 - 5. 3 inch to 4 inch
- C. Seal Class: All ductwork shall receive Class A Seal.
- D. Round Ducts: Furnish duct and fittings made by the same manufacturer to ensure good fit of slip joints. When submitted and approved in advance, round and flat oval duct, with size converted on the basis of equal pressure drop, may be furnished in lieu of rectangular duct design shown in the contract documents.
 - 1. Elbows: Diameters 75 through 203 mm (3 through 8 inches) shall be two sections die stamped, all others shall be gored construction, maximum 18 degree angle, with all seams continuously welded or standing seam. Coat galvanized areas of fittings damaged by welding with corrosion resistant aluminum paint or galvanized repair compound.
 - 2. Provide bell mouth, conical tees or taps, laterals, reducers, and other low loss fittings as shown in SMACNA HVAC Duct Construction Standards, Metal and Flexible.
 - 3. Ribbed Duct Option: Lighter gauge round/oval duct and fittings may be furnished provided certified tests indicating that the rigidity and performance is equivalent to SMACNA standard gauge ducts are submitted.
 - a. Ducts: Manufacturer's published standard gauge, G90 coating, spiral lock seam construction with an intermediate standing rib.
 - b. Fittings: May be manufacturer's standard as shown in published catalogs, fabricated by spot welding and bonding with neoprene base cement or machine formed seam in lieu of continuous welded seams.

4. Provide flat side reinforcement of oval ducts as recommended by the manufacturer and SMACNA HVAC Duct Construction Standards, Metal and Flexible. Because of high pressure loss, do not use internal tie-rod reinforcement unless approved by the COR.

E. Casings and Plenums: Construct in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, including curbs, access doors, pipe penetrations, eliminators and drain pans. Access doors shall be hollow metal, insulated, with latches and door pulls, 508 mm (20 inches) wide by 1219 to 1372 mm (48 to 54 inches) high. Provide view port in the doors where shown. Provide drain for outside air louver plenum. Outside air plenum shall have exterior insulation. Drain piping shall be routed to the nearest floor drain.

F. Volume Dampers: Single blade or opposed blade, multi-louver type as detailed in SMACNA Standards. Refer to SMACNA for Single Blade and Multi-blade Volume Dampers.

G. Duct Hangers and Supports: Refer to SMACNA Standards. Avoid use of trapeze hangers for round duct.

2.3 DUCT LINER (WHERE INDICATED IN THE CONTRACT DOCUMENTS) (NOT USED)

2.4 DUCT ACCESS DOORS, PANELS AND SECTIONS

A. Provide access doors, sized and located for maintenance work, upstream, in the following locations:

1. Each fire damper (for link service), smoke damper and automatic control damper.
2. Each duct mounted smoke detector.

B. Openings shall be as large as feasible in small ducts, 305 mm by 305 mm (12 inch by 12 inch) minimum where possible. Access sections in insulated ducts shall be double-wall, insulated. Transparent shatterproof covers are preferred for uninsulated ducts.

1. For Rectangular Ducts: Refer to SMACNA HVAC Duct Construction Standards, Metal and Flexible.
2. For Round and Flat Oval Ducts: Refer to SMACNA HVAC Duct Construction Standards, Metal and Flexible.

2.5 FIRE DAMPERS

A. Galvanized steel, interlocking blade type, UL listing and label, 1-1/2-hour rating, 70 degrees C (158 degrees F) fusible line, 100 percent

03-01-23

free opening with no part of the blade stack or damper frame in the air stream.

- B. Fire dampers in wet air exhaust shall be of stainless-steel construction, all others may be galvanized steel.
- C. Minimum Requirements for Fire Dampers:
 - 1. The damper frame may be of design and length as to function as the mounting sleeve, thus eliminating the need for a separate sleeve, as allowed by UL 555. Otherwise provide sleeves and mounting angles, minimum 1.9 mm (14 gauge), required to provide installation equivalent to the damper manufacturer's UL test installation.
 - 2. Submit manufacturer's installation instructions conforming to UL rating test.

2.6 SMOKE DAMPERS (NOT USED)

2.7 FIRE DOORS (NOT USED)

2.8 FLEXIBLE AIR DUCT

- A. General: Factory-fabricated, complying with NFPA 90A for connectors not passing through floors of buildings. Flexible ducts shall not penetrate any fire or smoke barrier which is required to have a fire resistance rating of one hour or more. Flexible duct length shall not exceed 1.5 m (5 feet). Provide insulated acoustical air duct connectors in supply air duct systems and elsewhere as shown.
- B. Flexible ducts shall be listed by Underwriters Laboratories, Inc., complying with UL 181. Ducts greater than 203 mm (8 inches) in diameter shall be Class 1. Ducts less than 203 mm (8 inches) in diameter shall be Class 1 or Class 2.
- C. Insulated Flexible Air Duct: Factory-fabricated including mineral fiber insulation with maximum C factor of 0.25 at 24 degrees C (75 degrees F) mean temperature, encased with a low permeability moisture barrier outer jacket, having a puncture resistance of not less than 50 Beach Units. Acoustic insertion loss shall not be less than 3 dB per 300 mm (foot) of straight duct, at 500 Hz, based on 152 mm (6 inch) duct, of 762 m/min (2500 fpm).
- D. Application Criteria:
 - 1. Temperature Range: -18 to 93 degrees C (0 to 200 degrees F) internal.
 - 2. Maximum Working Velocity: 1219 m/min (4000 fpm).

3. Minimum Working Pressure, Inches of Water Gauge: 2500 Pa (10 inches WG) positive, 500 Pa (2 inches WG) negative.
- E. Duct Clamps: 100 percent nylon strap, 80 kg (176 pounds) minimum loop tensile strength manufactured for this purpose or stainless-steel strap with cadmium plated worm gear tightening device. Apply clamps with sealant and as approved for UL 181, Class 1 installation.
- F. Flexible air duct is prohibited in operating room suites, SPS processing spaces, Pharmacy compounding spaces, Protective Environment spaces, Isolation Rooms, Clean Rooms, Bio-containment Laboratories, Research Laboratories, and Clinical Laboratories.

2.9 FLEXIBLE DUCT CONNECTIONS

- A. Where duct connections are made to fans, air terminal units, and air handling units, install a non-combustible flexible connection of 822 g (29 ounces) neoprene coated fiberglass fabric approximately 152 mm (6 inches) wide. For connections exposed to sun and weather provide hypalon coating in lieu of neoprene. Burning characteristics shall conform to NFPA 90A. Securely fasten flexible connections to round ducts with stainless-steel or zinc-coated iron draw bands with worm gear fastener. For rectangular connections, crimp fabric to sheet metal and fasten sheet metal to ducts by screws 50 mm (2 inches) on center. Fabric shall not be stressed other than by air pressure. Allow at least 25 mm (one inch) slack to ensure that no vibration is transmitted.

2.10 SOUND ATTENUATING UNITS (NOT USED)

2.11 PREFABRICATED ROOF CURBS

- A. Galvanized steel or extruded aluminum 305 mm (12 inches) above finish roof service, continuous welded corner seams, treated wood nailer, 38 mm (1-1/2 inch) thick, 48 kg/cubic meter (3 pound/cubic feet) density rigid mineral fiberboard insulation with metal liner, built-in cant strip (except for gypsum or tectum decks). For surface insulated roof deck, provide raised cant strip (recessed mounting flange) to start at the upper surface of the insulation. Curbs shall be constructed for pitched roof or ridge mounting as required to keep top of curb level.

2.12 FIRESTOPPING MATERIAL

- A. Refer to Section 07 84 00, FIRESTOPPING.

2.13 SEISMIC RESTRAINT FOR DUCTWORK (NOT USED)

2.14 DUCT MOUNTED THERMOMETER (AIR)

- A. Stem Type Thermometers: ASTM E1, 7 inch scale, red appearing mercury, lens front tube, cast aluminum case with enamel finish and clear glass or polycarbonate window, brass stem, 2 percent of scale accuracy to ASTM E77 scale calibrated in degrees Fahrenheit.
- B. Thermometer Supports:
 - 1. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.
 - 2. Flange: 75 mm (3 inch) outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

2.15 DUCT MOUNTED TEMPERATURE SENSOR (AIR)

- A. Refer to Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

2.16 INSTRUMENT TEST FITTINGS

- A. Manufactured type with a minimum 50 mm (2 inch) length for insulated duct, and a minimum 25 mm (1 inch) length for duct not insulated. Test hole shall have a flat gasket for rectangular ducts and a concave gasket for round ducts at the base, and a screw cap to prevent air leakage.
- B. Provide instrument test holes at each duct or casing mounted temperature sensor or transmitter, and at entering and leaving side of each heating coil, cooling coil, and heat recovery unit.

2.17 AIR FLOW CONTROL VALVES (AFCV)

- A. Refer to Section 23 36 00, AIR TERMINAL UNITS and Section 23 82 00, CONVECTION HEATING and COOLING UNITS.

2.18 LEAD COVERED DUCT (NOT USED)

2.19 ELECTROSTATIC SHIELDING (NOT USED)

PART 3 - EXECUTION

3.1 INSTALLATION

- A. If an installation is unsatisfactory to the COR, the contractor shall correct the installation at no additional cost or time to the Government.
- B. Comply with provisions of Section 23 05 11, COMMON WORK RESULTS FOR HVAC, particularly regarding coordination with other trades and work in existing buildings.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
Bancroft Architects + Engineers

03-01-23

- C. Fabricate and install ductwork and accessories in accordance with referenced SMACNA Standards:
1. Contract documents show the general layout of ductwork and accessories but do not show all required fittings and offsets that may be necessary to connect ducts to equipment, boxes, diffusers, grilles, etc., and to coordinate with other trades. Fabricate ductwork based on field measurements. Provide all necessary fittings and offsets at no additional cost to the Government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories on ceiling grid. Duct sizes in the contract documents are inside dimensions which shall be altered by Contractor to other dimensions with the same air handling characteristics where necessary to avoid interferences and clearance difficulties.
 2. Provide duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA Standards. Provide streamliner, when an obstruction cannot be avoided and must be taken in by a duct. Repair galvanized areas with galvanizing repair compound.
 3. Provide bolted construction and tie-rod reinforcement in accordance with SMACNA Standards.
 4. Construct casings, eliminators, and pipe penetrations in accordance with SMACNA Standards. Design casing access doors to swing against air pressure so that pressure helps to maintain a tight seal.
- D. Install duct hangers and supports in accordance with SMACNA Standards.
- E. Install fire dampers and smoke dampers in accordance with the manufacturer's instructions to conform to the installation used for the rating test. Install fire dampers and smoke dampers at locations indicated and where ducts penetrate fire rated and/or smoke rated walls, shafts and where required by the COR. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges per UL and NFPA. Demonstrate resetting of fire dampers and operation of smoke dampers to the COR.
- F. Seal openings around duct penetrations of floors and fire rated partitions with fire stop material as required by NFPA 90A.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
Bancroft Architects + Engineers

03-01-23

- G. Flexible Duct Installation: Refer to SMACNA Standards. Ducts shall be continuous, single pieces not over 1.5 m (5 feet) long per NFPA 90A, as straight and short as feasible, adequately supported. Centerline radius of bends shall be not less than two duct diameters. Make connections with clamps as recommended by SMACNA. Clamp per SMACNA with one clamp on the core duct and one on the insulation jacket. Flexible ducts shall not penetrate floors, or any chase or partition designated as a fire or smoke barrier, including corridor partitions fire rated one hour or two hours. Support ducts SMACNA Standards.
- H. Where diffusers, registers and grilles cannot be installed to avoid seeing inside the duct, paint the inside of the duct with flat black paint to reduce visibility.
- I. Control Damper Installation:
1. Provide necessary blank-off plates required to install dampers that are smaller than duct size. Provide necessary transitions required to install dampers larger than duct size.
 2. Assemble multiple sections dampers with required interconnecting linkage and extend required number of shafts through duct for external mounting of damper motors.
 3. Provide necessary sheet metal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation, and affix and seal permanently in place, only after stratification problem has been eliminated.
 4. Install all damper control/adjustment devices on stand-offs to allow complete coverage of insulation.
- J. Air Flow Measuring Devices: Install units with minimum straight run distances, upstream and downstream as recommended by the manufacturer.
- K. Low Pressure Duct Liner: Install in accordance with SMACNA Standards.
- L. Protection and Cleaning: Adequately protect equipment and materials against physical damage. Place equipment in first class operating condition or return to source of supply for repair or replacement, as determined by COR. Protect equipment and ducts during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting. When new ducts are connected to existing ductwork, clean both new and existing ductwork by mopping and vacuum cleaning inside and outside before operation.

3.2 DUCT LEAKAGE TESTS AND REPAIR

- A. Ductwork leakage testing shall be performed by the Testing and Balancing Contractor directly contracted by the General Contractor and independent of the Sheet Metal Contractor.
- B. Ductwork leakage testing shall be performed for the entire air distribution system (including all supply, return, exhaust and relief ductwork), section by section, including fans, coils and filter sections.
- C. Test procedure, apparatus and report shall conform to SMACNA HVAC Air Duct Leakage Test Manual. The maximum leakage rate allowed is 4 percent of the design air flow rate.
- D. All ductwork shall be leak tested first before enclosed in a shaft or covered in other inaccessible areas.
- E. All tests shall be performed in the presence of the COR and the Test and Balance agency. The Test and Balance agency shall measure and record duct leakage and report to the COR and identify leakage source with excessive leakage.
- F. If any portion of the duct system tested fails to meet the permissible leakage level, the Contractor shall rectify sealing of ductwork to bring it into compliance and shall retest it until acceptable leakage is demonstrated to the COR.
- G. All tests and necessary repairs shall be completed prior to insulation or concealment of ductwork.
- H. Make sure all openings used for testing flow and temperatures by TAB Contractor are sealed properly.

3.3 DUCTWORK EXPOSED TO WIND VELOCITY (NOT USED)

3.4 TESTING, ADJUSTING, AND BALANCING (TAB)

- A. Refer to Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.

3.5 OPERATING AND PERFORMANCE TESTS

- A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

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SECTION 23 34 00
HVAC FANS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Fans for heating, ventilating and air conditioning.
- C. Product Definitions: AMCA 99.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.
- D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
- E. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- F. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.
- G. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- H. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.
- I. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- J. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- K. Section 26 29 11, MOTOR CONTROLLERS.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standards will govern.
- B. Air Movement and Control Association International, Inc. (AMCA):
 - 99-2016.....Standards Handbook
 - 210-2016.....Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
 - 300-2014.....Reverberant Room Method for Sound Testing of Fans
- C. American Society for Testing and Materials (ASTM):
 - B117-2019.....Standard Practice for Operating Salt Spray (Fog) Apparatus

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
Bancroft Architects + Engineers

03-01-23

- D1735-2014.....Standard Practice for Testing Water Resistance
of Coatings Using Water Fog Apparatus
- D3359-2017.....Standard Test Methods for Rating Adhesion by
Tape Test
- G152-2013 (R2021).....Standard Practice for Operating Open Flame
Carbon Arc Light Apparatus for Exposure of
NonMetallic Materials
- G153-2013 (R2021).....Standard Practice for Operating Enclosed Carbon
Arc Light Apparatus for Exposure of NonMetallic
Materials
- D. National Fire Protection Association (NFPA):
NFPA 96-2021.....Standard for Ventilation Control and Fire
Protection of Commercial Cooking Operations
- E. National Sanitation Foundation (NSF):
37-2020 Air Curtains for Entranceways in Food and Food
Service Establishments
- F. Underwriters Laboratories, Inc. (UL):
181-2013.....Standard for Factory-Made Air Ducts and Air
Connectors

1.4 SUBMITTALS

- A. Submittals, including number of required copies, shall be submitted in
accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND
SAMPLES.
- B. Information and material submitted under this section shall be marked
"SUBMITTED UNDER SECTION 23 XX XX, SECTION TITLE", with applicable
paragraph identification.
- C. Manufacturers Literature and Data Including: Full item description and
optional features and accessories. Include dimensions, weights,
materials, applications, standard compliance, model numbers, size, and
capacity.
1. Propeller fans.
- D. Certified sound power levels for each fan.
- E. Motor ratings, types, electrical characteristics, and accessories.
- F. Certified fan performance curves for each fan showing cubic feet per
minute (CFM) versus static pressure, efficiency, and horsepower for
design point of operation.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier
Bancroft Architects + Engineers

03-01-23

G. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replaceable parts, and troubleshooting guide:

1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.
3. Diagrams shall have their terminals identified to facilitate installation, operation, and maintenance.

H. Completed System Readiness Checklist provided by the CxA and completed by the contractor, signed by a qualified technician, and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

I. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 QUALITY ASSURANCE

A. Fans and power ventilators shall bear the AMCA performance seal.

B. Operating Limits for Centrifugal Fans: AMCA 99 (Class I, II, and III).

C. Fans and power ventilators shall comply with the following standards:

1. Testing and Rating: AMCA 210.
2. Sound Rating: AMCA 300.

D. Vibration Tolerance for Fans and Power Ventilators: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

E. Performance Criteria:

1. The fan schedule shall show the design air volume and static pressure. Select the fan motor hp by increasing the fan bhp by 10 percent to account for the drive losses and field conditions.
2. Select the fan operating point as follows:
 - a. Forward Curve and Axial Flow Fans: Right hand side of peak pressure point.
 - b. Air Foil, Backward Inclined, or Tubular: At or near the peak static efficiency.

F. Safety Criteria: Provide manufacturer's standard screen on fan inlet and discharge where exposed to operating and maintenance personnel.

G. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.

1.6 AS-BUILT DOCUMENTATION

- A. Comply with requirements in paragraph AS-BUILT DOCUMENTATION of Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.7 EXTRA MATERIALS

- A. Provide one additional set of belts for all belt-driven fans.

PART 2 - PRODUCTS

2.1 PLENUM FAN (NOT USED)

2.2 CENTRIFUGAL FANS (NOT USED)

2.3 POWER ROOF VENTILATOR (NOT USED)

2.4 POWER WALL VENTILATOR (NOT USED)

2.5 PACKAGED HOOD MAKE-UP AIR UNITS (NOT USED)

2.6 CENTRIFUGAL CEILING FANS (NOT USED)

2.7 PROPELLER FANS

- A. Belt-driven or direct-driven fans as indicated in the contract documents.
- B. Square steel panel, deep drawn venturi, arc welded to support arms and fan/motor support brackets, baked enamel finish. Provide wall collar for thru-wall installations.
- C. Motor, Motor Base and Drive: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC. Motor shall be totally enclosed type.
- D. Wall Shutter: Fan manufacturer's standard, steel frame, aluminum blades, heavy duty stall type electric damper motor, spring closed.
- E. Wire Safety Guards: Provide on exposed inlet and outlet.

2.8 VANE AXIAL FANS (NOT USED)

2.9 AIR CURTAIN UNITS (NOT USED)

PART 3 - EXECUTION

3.1 INSTALLATION

- A. If an installation is unsatisfactory to the COR, the contractor shall correct the installation at no additional cost or time to the Government.
- B. Install fan, motor and drive in accordance with manufacturer's instructions.
- C. Align fan and motor sheaves to allow belts to run true and straight.
- D. Bolt equipment to curbs with galvanized lag bolts.

- E. Install vibration control devices as shown in the contract documents and specified in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

3.2 PRE-OPERATION MAINTENANCE

- A. Lubricate bearings, pulleys, belts and other moving parts with manufacturer recommended lubricants.
- B. Rotate impeller by hand and check for shifting during shipment and check all bolts, collars, and other parts for tightness.
- C. Clean fan interiors to remove foreign material and construction dirt and dust.

3.3 STARTUP AND TESTING

- A. Verify operation of motor, drive system and fan wheel according to the contract documents.
- B. Check vibration and correct as necessary for air balance work.
- C. After air balancing is complete and permanent sheaves are in place perform necessary field mechanical balancing to meet vibration tolerance in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- D. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.
- E. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.
- F. The CxA will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and CxA. Provide a minimum notice of 10 working days prior to startup and testing.

3.3 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- B. Components provided under this section of the specification will be tested as part of a larger system.

03-01-23

3.4 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-01-23

SECTION 23 81 00
DECENTRALIZED UNITARY HVAC EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies rooftop air conditioners.
- B. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- C. Definitions:
 - 1. Energy Efficiency Ratio (EER): The ratio of net cooling capacity is Btu/h to total rate of electricity input in watts under designated operating conditions (Btu hour/Watt).
 - 2. Seasonal Energy Efficiency Ratio (EER): The ratio of the total cooling output of an air conditioner during its normal annual usage period for cooling in Btu/h divided by total electric energy input in watts during the same period (Btu hour/Watt).
 - 3. Unitary: A Unitary Air Conditioner consists of one or more factory-made assemblies which normally include an evaporator or cooling coil, a compressor and condenser combination, and may include a heating function as well.
 - 4. Where such equipment is provided in greater than one assembly the separated assemblies are to be designed to be used together and the requirements of rating are based upon use of matched assemblies.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.
- D. Section 03 30 00, CAST-IN-PLACE CONCRETE.
- E. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- F. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.
- G. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- H. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.
- I. Section 23 07 11, HVAC and BOILER PLANT INSULATION.
- J. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- K. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-01-23

- L. Section 23 23 00, REFRIGERANT PIPING.
- M. Section 23 31 00, HVAC DUCTS and CASINGS.
- N. Section 23 81 23, COMPUTER-ROOM AIR-CONDITIONERS.
- O. Section 28 31 00, FIRE DETECTION and ALARM.

1.3 SUBMITTALS

- A. Submit in accordance with specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES
- B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 81 00, DECENTRALIZED UNITARY HVAC EQUIPMENT", with applicable paragraph identification.
- C. Manufacturer's literature and data Including:
 - 1. Sufficient information, including capacities, pressure drops, and piping connections clearly presented, shall be included to determine compliance with contract documents for units noted below:
 - a. Unitary air conditioners:
 - 1) Self-contained units
 - 2) Split systems
 - 3) Rooftop units
 - 2. Unit Dimensions required clearances, operating weights accessories and start-up instructions.
 - 3. Electrical requirements, wiring diagrams, interlocking and control wiring showing factory installed and portions to be field installed.
 - 4. Mounting and flashing of the roof curb to the roofing structure with coordinating requirements for the roof membrane system.
- D. Certification: Submit proof of specified ARI Certification.
- E. Performance Rating: Submit catalog selection data showing equipment ratings and compliance with required sensible-to-heat-ratio, integrated energy efficiency ratio (IEER), and coefficient of performance (COP).
- F. Operating and Maintenance Manual: Submit three copies of Operating and Maintenance manual to COR three weeks prior to final inspection.
- G. Completed System Readiness Checklists provided by the CxA and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

1.4 QUALITY ASSURANCE

A. Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-01-23

- B. Safety Standards: ASHRAE Standard 15, Safety Code for Mechanical Refrigeration.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standards will govern.
- B. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):
- 210/240-2023(2020).....Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment
- 270-2015.....Sound Rating of Outdoor Unitary Equipment
- 310/380-2017.....Standard for Packaged Terminal Air-Conditioners and Heat Pumps (CSA-C744-04)
- 340/360-(I-P 2019).....Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment
- 520-2004.....Performance Rating of Positive Displacement Condensing Units
- C. Air Movement and Control Association (AMCA):
- 210-2016.....Laboratory Methods of Testing Fans for Aerodynamic Performance Rating (ANSI)
- 410-1996.....Recommended Safety Practices for Users and Installers of Industrial and Commercial Fans
- D. American National Standards Institute (ANSI):
- S12.51-2012(R2020).....Acoustics - Determination of Sound Power Levels of Noise Sources Using Sound Pressure - Precision Method for Reverberation Rooms (same as ISO 3741:1999)
- E. American Society of Civil Engineers (ASCE)
- ASCE 7-2017.....Minimum Design Loads for Buildings and Other Structures
- F. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
- Handbook 2016.....HVAC Systems and Equipment
- 15-2019.....Safety Standard for Refrigeration Systems (ANSI)

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-01-23

62.1-2019.....Ventilation for Acceptable Indoor Air Quality
(ANSI)

G. American Society of Testing and Materials (ASTM):

B117-2019.....Standard Practice for Operating Salt Spray
(Fog) Apparatus

H. Military Specifications (Mil. Specs.):

MIL-PRF-26915D-2006.....Primer Coating, for Steel Surfaces

I. National Electrical Manufacturer's Association (NEMA):

ICS 1-2005.....Industrial Controls and Systems: General
Requirements

MG 1-2016 (R2019).....Motors and Generators (ANSI)

J. National Fire Protection Association (NFPA) Publications:

90A-2021.....Standard for the Installation of Air-
Conditioning and Ventilating Systems

1.6 AS-BUILT DOCUMENTATION

A. Comply with requirements in Paragraph "AS-BUILT DOCUMENTATION" in
Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

PART 2 - PRODUCTS

2.1 UNITARY AIR CONDITIONERS - GENERAL

A. Applicable ARI Standards:

1. Cooling Capacity 39.6 kW (135,000 Btu/hour) and greater: AHRI 340/
360.

2. Cooling Capacity Less Than 39.6 kW (135,000 Btu/hour): AHRI 210/240.
Units shall be listed in the ARI Directory of Certified Unitary Air-
Conditioners.

B. Performance Rating: Cooling capacity of units shall meet the sensible
heat and total heat requirements shown in the contract documents. In
selecting unit size, make true allowance for "sensible to total heat
ratio" to satisfy required sensible cooling capacity.

C. Machinery Guards: Provide guards as shown in AMCA 410 for belts,
chains, couplings, pulleys, sheaves, shafts, gears and other moving
parts regardless of height above the floor. Drive guards may be
excluded where motors and drives are inside factory fabricated casings.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-01-23

2.2 SELF-CONTAINED AIR CONDITIONERS (NOT USED)

2.3 SPLIT-SYSTEM AIR CONDITIONERS

- A. Description: Factory assembled and tested, ceiling mounted unit, with an air-cooled remote condensing unit, and field-installed refrigeration piping. Unit shall include a hot-water heating coil.
- B. Concealed Evaporator Components:
1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
 2. Insulation: Factory-applied duct liner.
 3. Drain Pans: Galvanized steel, with connection for drain; insulated and complying with ASHRAE 62.1.
 4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 5. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with AHRI 210/240, and with thermal-expansion valve.
 6. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 10 fins per 25 mm (1 inch); leak tested to 2070 kPa (300 psig) underwater; and having a modulating control valve.
 7. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
 8. Fan Motors: Comply with requirements in Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT for multi-tapped, multi-speed motors with internal thermal protection and permanent lubrication.
 9. Disposable Filters: 25 mm (1 inch) thick, in fiberboard frames with MERV rating of 7 or higher according to ASHRAE 52.2.
 10. Wiring Terminations: Connect motor to chassis wiring with plug connection.
- C. Ceiling-Mounting, Evaporator-Fan Components:
1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 3. Drain Pan and Drain Connection: Comply with ASHRAE 62.1.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-01-23

4. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with AHRI 210/240, and with thermal-expansion valve.
 5. Electric-Resistance Heating Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.
 6. Fan: Direct drive, centrifugal fan, and integral condensate pump.
 7. Fan Motors: Comply with requirements in Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT for multi-tapped, multi-speed motors with internal thermal protection and permanent lubrication.
 8. Filters: Disposable, with MERV rating of 7 or higher according to ASHRAE 52.2.
- D. Air-Cooled, Compressor-Condenser Components:
1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Service valves, fittings, and gauge ports shall be brass and located outside of the casing.
 2. Compressor: Hermetically sealed reciprocating with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 3. Compressor motor with manual-reset, high-pressure switch and automatic-reset, low-pressure switch.
 4. Refrigerant: R-410A unless otherwise indicated.
 5. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with AHRI 210/240, and with liquid subcooler.
 6. Fan: Aluminum, propeller type, directly connected to motor.
 7. Motor: Permanently lubricated, with integral thermal-overload protection.
 8. Low Ambient Kit: Permit operation down to minus 18 degrees C (0 degrees F).
 9. Mounting Base: Polyethylene.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-01-23

10. Minimum Energy Efficiency: Comply with ASHRAE/IESNA 90.1 "Energy Standard for Buildings except Low-Rise Residential Buildings."

2.4 ROOFTOP AIR CONDITIONERS

- A. Casing: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed. Exterior casing of galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs. Galvanized inner casing of perforated 40 percent free area. Casing insulation and adhesive shall comply with NFPA 90A or NFPA 90B and comply with ASTM C 1071, Type I and shall be 1/2 inch thick. Space between double wall panels filled with foam insulation and sealed moisture tight. Removable cam latched access panel to allow access to internal parts.
- B. Corrosion Prevention: Paint shall be treated for prevention of rust with a factory coating or paint system that will withstand 500 hours in a salt-spray fog test. The salt-spray fog test shall be in accordance with ASTM B117 using a 20 percent sodium chloride solution. Refer to contract documents and Section 23 82 16, AIR COILS, for additional coil requirements.
- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Condenser-Coil Fan: Propeller, mounted on shaft of permanently lubricated motor.
- E. Fan Motor: Comply with requirements in Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.
- F. Supply-Air Refrigerant Coil: Aluminum -plate fins and seamless copper tube in steel casing with equalizing-type vertical distributor. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan. Coil split shall be interlaced.
- G. Condensate Drain Pan: Formed sections of stainless-steel sheet, a minimum of 50 mm (2 inches) deep and complying with ASHRAE 62.1. Drain connections shall be threaded nipple .
- H. Outdoor-Air Refrigerant Coil: Aluminum -plate fins and seamless copper tube in steel casing with equalizing-type vertical distributor. Polymer strip shall prevent copper coil from contacting steel coil frame or

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-01-23

condensate pan. Coil shall have baked phenolic or cathodic epoxy coating.

- I. Hot-Gas Reheat Refrigerant Coil: Aluminum -plate fins and seamless copper tube in steel casing with equalizing-type vertical distributor. Polymer strip shall prevent copper coil from contacting steel coil frame or condensate pan. Coil shall have baked phenolic or cathodic epoxy coating.

J. Refrigerant Circuit Components:

1. Number of Independent Refrigerant Circuits: One.
2. Compressor: Hermetic, scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.

K. Refrigerant: R-410A unless otherwise indicated.

L. Refrigeration Specialties:

1. Expansion valve with replaceable thermostatic element.
2. Refrigerant filter/dryer.
3. Manual-reset high-pressure safety switch.
4. Automatic-reset low-pressure safety switch.
5. Minimum off-time relay.
6. Automatic-reset compressor motor thermal overload.
7. Brass service valves installed in compressor suction and liquid lines.
8. Low-ambient kit high-pressure sensor.
9. Hot-gas reheat solenoid valve with a replaceable magnetic coil.
10. Hot-gas bypass solenoid valve with a replaceable magnetic coil.
11. Four-way reversing valve with a replaceable magnetic coil, thermostatic expansion valves with bypass check valves, and a suction line accumulator.

M. Air Filtration: Minimum arrestance according to ASHRAE 52.1, and MERV rating according to ASHRAE 52.2.

1. Pleated: Minimum 90 percent arrestee, and MERV 7.

N. Outdoor-Air Damper: Linked damper blades, for 0 to 25 percent outdoor air, with manual damper filter.

O. Outdoor- and Return-Air Mixing Dampers: Parallel- or opposed-blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-01-23

rods with common linkage and interconnect linkages so dampers operate simultaneously.

- P. Damper Motor: Modulating with adjustable minimum position.
- Q. Relief-Air Damper: Gravity actuated or motorized, complying with ASHRAE/IESNA 90.1, and having bird screen and hood.
- R. Electrical Power Connection: A single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.
- S. Controls:
 - 1. Basic Unit Controls:
 - a. Control-voltage transformer.
 - b. Wall-mounted thermostat or sensor with heat-cool-off switch.
 - c. Fan on-auto switch.
 - d. Fan-speed switch.
 - e. Automatic changeover.
 - f. Adjustable deadband.
 - g. Concealed set point.
 - h. Concealed indication.
 - i. Degree F indication.
 - j. Unoccupied-period-override push button.
 - k. Data entry and access port to input temperature set points, occupied and unoccupied periods, and output room temperature, supply-air temperature, operating mode, and status.
 - l. Remote wall annunciator panel with lights to indicate power on, cooling, heating, fan running, filter dirty, and unit alarm or failure.
 - m. DDC controller or programmable timer and interface with HVAC instrumentation and control system and to digital display outdoor-air temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters. Interface with BMS/DDC system via BACnet open protocol.
 - 2. DDC controller shall have volatile-memory backup.
 - 3. Safety Control Operation:

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-01-23

- a. Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected and with additional contacts for alarm interface to fire alarm control panel.
- b. Fire Stats: Stop fan and close outdoor-air damper if air greater than 54 degrees C (130 degrees F)] enters unit and with additional contacts for alarm interface to fire alarm control panel.
- c. Fire Alarm Control Panel Interface: Control interface to coordinate with operating sequence described in Section 28 31 00, FIRE DETECTION and ALARM.
- d. Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply air temperature is less than 4 degrees C (40 degrees F)].
- e. Defrost Control for Condenser Coil: Pressure differential switch to initiate defrost sequence.
4. Scheduled Operation: Occupied and unoccupied periods on 7 -day clock with a minimum of 2 programmable periods per day.
5. Unoccupied Period: Heating Setback: 5.6 degrees C (10 degrees F)].
6. Cooling Setback: System off.
7. Override Operation: Two hours unless otherwise indicated.
8. Supply Fan Operation:
 - a. Occupied Periods: Run fan continuously.
 - b. Unoccupied Periods: Cycle fan to maintain setback temperature.
9. Refrigerant Circuit Operation:
 - a. Occupied Periods: Cycle or stage compressors and operate hot-gas bypass to match compressor output to cooling load to maintain room temperature. Cycle condenser fans to maintain maximum hot-gas pressure. Operate low-ambient control kit to maintain minimum hot-gas pressure.
 - b. Unoccupied Periods: Compressors off
10. Fixed Minimum Outdoor-Air Damper Operation:
 - a. Occupied Periods: Open to 25 percent.
 - b. Unoccupied Periods: Close the outdoor-air damper.
11. Economizer Outdoor-Air Damper Operation:
 - a. Occupied Periods: Open to 25 percent fixed minimum intake, and maximum 100 percent of the fan capacity to comply with ASHRAE

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-01-23

Cycle II. Controller shall permit air-side economizer operation when outdoor air is less than 15 degrees C (60 degrees F). Use outdoor-air temperature and select between outdoor-air and return-air enthalpy to adjust mixing dampers. Start relief-air fan with end switch on outdoor-air damper. During economizer cycle operation, lock out cooling.

- b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.
- 12. Outdoor-Airflow Monitor: Accuracy maximum plus or minus 5 percent within 15 and 100 percent of total outdoor air. Monitor microprocessor shall adjust for temperature, and output shall range from 2- to 10-V dc.
- 13. Interface Requirements for HVAC Instrumentation and Control System:
 - a. Interface relay for scheduled operation.
 - b. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
 - c. Compatible with BACnet for central HVAC control workstation for adjusting set points, monitoring supply fan start, stop, and operation, inquiring data to include outdoor-air damper position, monitoring occupied and unoccupied operations, monitoring constant and variable motor loads, monitoring variable-frequency drive operation, monitoring cooling load, monitoring economizer cycles and monitoring air-distribution static pressure and ventilation air volume.

T. Accessories:

- 1. Electric heater with integral thermostat maintains minimum 10 degrees C (50 degrees F) temperature in gas burner compartment.
- 2. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.
- 3. Low-ambient kit using staged condenser fans for operation down to 1.7 degrees C (35 degrees F).
- 4. Filter differential pressure switch with sensor tubing on both sides of filter. Set for final filter pressure loss.
- 5. Coil guards of painted, galvanized-steel wire.
- 6. Hail guards of galvanized steel painted to match casing.

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-01-23

7. Concentric diffuser with white louvers and polished aluminum return grilles, insulated diffuser box with mounting flanges, and interior transition.

U. Roof curbs: Vibration isolators and wind or seismic restraints shall be as specified in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT. Manufacturer's standard curbs constructed of galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Factory applied and complying with NFPA 90A or NFPA 90B and ASTM C 1071, Type I or II. Thickness shall be 25 mm (1 inch). Insulation shall be applied with adhesive and mechanical fasteners to the internal surface of curb. Liner adhesive shall comply with ASTM C 916, Type I. Liner shall be fastened with mechanical fasteners of galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied without causing leakage in cabinet. Liner materials shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity. Liner adhesive shall comply with ASTM C 916, Type I.

2. Curb Height: 24 inches.

3. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match RTU, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT for wind-load requirements.

2.5 ROOM-TYPE AIR CONDITIONERS (NOT USED)

2.6 PACKAGED TERMINAL AIR CONDITIONERS (NOT USED)

2.7 GAS-FIRED FURNACES (NOT USED)

PART 3 - EXECUTION

3.1 INSTALLATION

A. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-01-23

07 72 00, ROOF ACCESSORIES. Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

- B. Rooftop Unit Support: Install unit level on structural curbs . Coordinate wall penetrations and flashing with wall construction. Secure rooftop units to structural support with anchor bolts.
- C. Install wind restraints according to manufacturer's written instructions. Wind restrained vibration isolation roof-curb rails are specified in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- D. Install units level and plumb maintaining manufacturer's recommended clearances and tolerances.
- E. Install water-cooled units with thermometer and pressure gauge at the water supply and return connection.
- F. Install vibration spring isolators under base of self-contained unit, with minimum static deflection of 25 mm (1 inch) unless otherwise indicated. Refer to Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT
- G. Install ground-mounting, compressor-condenser components on 100 mm (4-inch) thick, reinforced concrete base; 100 mm (4 inches) greater on each side than unit. Concrete, reinforcement, and formwork are specified in Section 03 30 00, CAST-IN-PLACE CONCRETE. Coordinate anchor installation with concrete base.
- H. Install ground-mounting, compressor-condenser components on polyethylene mounting base.
- I. Install roof-mounting compressor-condenser components on equipment supports specified in Section 07 72 00, ROOF ACCESSORIES. Anchor units to supports with removable, cadmium-plated fasteners.
- J. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 25 mm (1 inch) unless otherwise indicated. Refer to Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- K. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.
- L. Install wall sleeves in finished wall assembly and weatherproof. Install and anchor wall sleeves to withstand, without damage seismic forces as required by code.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-01-23

3.2 CONNECTIONS

- A. Verify condensate drainage requirements.
- B. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.
- C. Install piping adjacent to units to allow service and maintenance.
- D. Gas Piping: Comply with applicable requirements in Section 23 11 23, FACILITY NATURAL-GAS PIPING. Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.
- E. Install ducts to termination at top of roof curb. Cut roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
- F. Connect supply ducts to units with flexible duct connectors specified in Section 23 31 00, HVAC DUCTS and CASINGS.
- G. Install return-air duct continuously through roof structure.
- H. Install normal-weight, 20.7-MPa (3000-psi), compressive strength (28-day) concrete mix inside roof curb, 100 mm (4 inches) thick.
- I. Ground equipment and install power wiring, switches, and controls for self-contained and split systems.
- J. Connect refrigerant piping to coils with shutoff valves on the suction and liquid lines at the coil and a union or flange at each connection at the coil and condenser.
- K. Install ducts to the units with flexible duct connections.
- L. Connect piping with shutoff duty valves on the supply and return side of the coil and unions at all connections and with a throttling valve on the return piping near the coil.
- M. Connect piping with shutoff duty valves on the supply and return side of the water-cooled condenser and unions at all connections and with a throttling valve on the return piping near the condenser
- N. Connect piping with shutoff duty valves and unions on the steam supply and condensate side of the steam coil. On the condensate line near the coil provide a strainer, trap and shutoff valve.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections: After installing units and after electrical circuitry has been energized, test units for compliance with

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-01-23

requirements. Inspect for and remove shipping bolts, blocks, and tie-down straps. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment. Remove and replace malfunctioning units and retest as specified above.

3.4 STARTUP AND TESTING

- A. The CxA will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and CxA. Provide a minimum of 7 days prior notice.
- B. Provide services of manufacturer's technical representative for four hours to instruct VA personnel in operation and maintenance of units.

3.5 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the CxA.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.6 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for 4 hours to instruct VA personnel in operation and maintenance of units.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS.

---END---

SECTION 23 81 23
COMPUTER-ROOM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies process cooling split systems air conditioning unit.
- B. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- C. Definitions:
 - 1. Energy Efficiency Ratio (EER): A ratio calculated by dividing the cooling capacity in Btu per hour by the power input in watts at any given set of rating conditions, expressed in Watts (Btu/h) per watt.
 - 2. Integrated Energy Efficiency Ratio (IEER): Calculated by weighting the EER values at different load capacities and adding them together. The formula is based in the approximate number of hours a unit spends at each load point throughout its life. A minimum of four loads points are used for the calculation.
 - 3. Coefficient of Performance (COP): A ratio calculated by dividing the change in heating or cooling capacity (Btu/h) to the energy consumed by the system (kW), expressed in Btu/kWh.
 - 4. Unitary (AHRI): Consists of one or more factory-made assemblies, which normally include an evaporator or cooling coil, a compressor and condenser combination, and may include a heating function.
 - 5. CRAC Units: Computer Room Air Conditioning Units.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.
- D. Section 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING.
- E. Section 22 11 00, FACILITY WATER DISTRIBUTION.
- F. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- G. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.
- H. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- I. Section 23 05 93: TESTING, ADJUSTING, and BALANCING FOR HVAC.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- J. Section 23 07 11, HVAC INSULATION.
- K. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- L. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- M. Section 23 23 00, REFRIGERANT PIPING.
- N. Section 23 31 00, HVAC DUCTS and CASINGS.

1.3 SUBMITTALS

- A. Submit in accordance with specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 81 23, COMPUTER-ROOM-AIR-CONDITIONERS", with applicable paragraph identification.
- C. Manufacturer's Literature and Data Including: Rated capacities (at design indoor and outdoor conditions), EER/COP, operating characteristics, required specialties and accessories. Submit published catalog selection data showing equipment ratings and compliance with required sensible ratio.
 - 1. Indoor Air Conditioning Unit
 - 2. Glycol Pump Package
 - 3. Dry Cooler
 - 4. Air Cooled Condensing Unit
- D. Submit detailed equipment assemblies with dimensions, operating weights, required clearances.
- E. Submit wiring diagrams for power, alarm and controls.
- F. Certification: Submit, simultaneously with shop drawings, a proof of certification:
- G. Completed System Readiness Checklists provided by the CxA and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.
- H. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.4 QUALITY ASSURANCE

- A. Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.5 GUARANTEE

- A. The unit shall be guaranteed against all mechanical defects in material, parts or workmanship and shall be repaired or replaced at the

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

Contractor's expense within the period of one year from final acceptance. Contractor shall adhere to a four-hour service response time to troubles during the guarantee period.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standards will govern.
- B. Air-Conditioning, Heating and Refrigeration Institute (AHRI) Standards:
- 210/240-2023 (2020).....Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment
- 340/360-(I-P 2019).....Performance Rating of Commercial and Industrial Unitary Air Conditioning and Heat Pump Equipment
- 410-2001.....Forced-Circulation Air-Cooling and Air-Heating Coils
- 460-2005.....Performance Rating of Remote Mechanical-Draft Air-Cooled Refrigerant Condensers
- 520-2004.....Performance Rating of Positive Displacement Condensing Units
- DCPP (Web-based).....Directory of Certified Product Performance - Applied Directory of Certified Products
- C. Air Movement and Control Association (AMCA):
- 210-2016.....Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating (ANSI)
- 410-1996.....Recommended Safety Practices for Users and Installers of Industrial and Commercial Fans
- D. American Society of Heating, Refrigerating, and Air-Conditioning Engineers Inc. (ASHRAE):
- 15-2019.....Safety Standard for Refrigeration Systems and Designation and Classification of Refrigerants (ANSI)
- 52.1-1992(withdrawn)....Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices used in General Ventilation for Removing Particulate Matter

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

62-1-2019.....Ventilation for Acceptable Indoor Air Quality
(ANSI)

90.1-2019 (I-P).....Energy Standard for Buildings except Low-Rise
Residential Buildings (ANSI Approved; IES Co-
sponsored)

2020 HVAC Systems and Equipment Handbook

2018 Refrigeration Handbook

E. American Society of Testing and Materials (ASTM):

B117-2017.....Standard Practice for Operating Salt Spray
(Fog) Apparatus

F. National Electrical Manufacturer's Association (NEMA):

MG 1-2016 (R2019).....Motors and Generators (ANSI)

G. National Fire Protection Association (NFPA) Publications:

70-2020.....National Electrical Code

90A-2021.....Standard for the Installation of Air-
Conditioning and Ventilating Systems

1.7 AS-BUILT DOCUMENTATION

A. Comply with requirements in Paragraph AS-BUILT DOCUMENTATION of Section
23 05 11, COMMON WORK RESULTS FOR HVAC.

PART 2 - PRODUCTS

2.1 FLOOR-MOUNTED UNITS 28 KW (8 TONS) AND LARGER

- A. Description: Packaged, factory assembled, prewired, and prepiped;
consisting of cabinet, fans, filters, humidifier, and controls.
- B. Cabinet and Frame: Welded steel, braced for rigidity, and supporting
compressors and other mechanical equipment and fittings.
- C. Doors and Access Panels: Galvanized steel with polyurethane gaskets,
hinges, and concealed fastening devices.
- D. Insulation: Thermally and acoustically insulate cabinet interior with -
25-mm (1-inch) thick 24 kilogram/cubic meter (1.5 pound/cubic foot)
high-density mineral fiber duct liner coated on airstream side.
- E. Finish of Interior Surfaces: Surfaces in contact with the airstream
shall comply with requirements in ASHRAE 62.1.
- F. Finish of Exterior Surfaces: Baked-on, textured vinyl enamel; color as
selected from manufacturer's standard colors to match computer
equipment.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- G. Supply-Air Fan(s): Double-inlet, forward-curved centrifugal statically and dynamically balanced.
- H. Drive:
1. Forward-Curved Centrifugal Fan(s): V-belt, with steel shaft with self-aligning ball bearings and cast-iron or steel sheaves, variable and adjustable-pitch motor sheave, minimum of two matched belts, with drive rated at a minimum of two times the nameplate rating of motor.
- I. Compressors: Hermetic scroll; variable speed with oil strainer, internal motor overload protection, resilient suspension system, crankcase heater, manual-reset high-pressure switch, and pump-down low-pressure switch. Compressors shall have multiple stages of cooling as listed on the drawing equipment schedule.
- J. Refrigeration Circuits: Two; each with hot-gas mufflers, thermal-expansion valve with external equalizer, liquid-line solenoid valve, liquid-line filter-dryer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
- K. Refrigerant: R-410A unless otherwise indicated.
- L. Refrigerant Evaporator Coil: Alternate-row or split-face-circuit, direct-expansion coil of seamless copper tubes expanded into aluminum fins.
1. Coil assembly shall be mounted over stainless-steel drain pan complying with ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.
- M. Remote Air-Cooled Refrigerant Condenser: Corrosion-resistant cabinet, copper-tube aluminum-fins coils arranged for two circuits, multiple direct-drive propeller fans with permanently lubricated ball bearings, and single-phase motors with internal overload protection and integral electric control panel and disconnect switch. Control capacity by cycling fans.
- N. Heating Coil:
1. Electric-Resistance Heating Coil: Enclosed finned-tube electric elements arranged for SCR control, with thermal safety switches, manual-reset overload protection, and branch-circuit over current protection.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

2. Refrigerant Heating Coil: Hot-gas coil of seamless copper tubes expanded into aluminum fins with three-way solenoid valve on first-stage refrigerant circuit.
3. Hot-Water Heating Coil: Seamless copper tubes expanded into aluminum fins with two-way modulating control valve and strainer.
 - a. Control Valve: Class 125 body.
 - b. Maximum Pressure Drop: 21 kPa (3 psig) at design flow rate.
 - c. Close-Off (Differential) Pressure Rating: 100 percent of pressure differential across valve or 100 percent of total system (pump) head.
4. Steam Heating Coil: Seamless copper tubes expanded into aluminum fins with two-way modulating control valve, strainer, and float-and-thermostatic trap.
 - a. Control Valve: Class 125 body.
 - b. Maximum Pressure Drop (103-kPa (15-psig) Steam): 80 percent of inlet steam pressure.
 - c. Close-Off (Differential) Pressure Rating: 150 percent of operating (inlet) pressure.
- O. Filter Extended-Surface, Disposable, Panel type: Pleated, lofted, nonwoven, reinforced cotton fabric; supported and bonded to welded wire grid; enclosed in cardboard frame with 50-mm (2-inch) thick, disposable, glass-fiber prefilter.
 1. Thickness: 50 mm (2 inches).
 2. Arrestance: 90 percent according to ASHRAE 52.1.
 3. MERV Rating: 7, according to ASHRAE 52.2.
- P. Humidifier:
 1. Infrared Humidifier: High-intensity quartz lamps mounted above stainless-steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; prepiped and using condensate water from cooling coils with stainless-steel or brass float-valve mechanism; located in bypass airstream; with flush-cycle timer and solenoid drain valve.
 2. Evaporative Pan Humidifier: Stainless-steel pan and cover, serviceable without disconnecting water, drain, or electrical connections; prepiped with stainless-steel or brass float-valve

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- mechanism; electric-resistance heating coil low-water-cutoff switch; flush-cycle timer; and solenoid drain valve.
3. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders, and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.
 4. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
 5. Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
 6. Drain Cycle: Field-adjustable drain duration and drain interval.
- Q. Controls:
1. Integral Electrical Controls: Unit-mounted electrical enclosure with piano-hinged door, grounding lug, combination magnetic starters with overload relays, circuit breakers and cover interlock, and fusible control-circuit transformer.
 - a. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
 2. Electronic-Control System: Solid state, with start button, stop button, temporary loss of power indicator, manual-reset circuit breakers, temperature control, humidity control, and monitor panel.
- R. Microprocessor-Control System: Continuously monitors operation of process cooling system; continuously displays room temperature and room relative humidity; sounds alarm on system malfunction and simultaneously displays problem. If more than one malfunction occurs, system displays fault in sequence with room temperature and continues to display fault when malfunction is cleared until system is reset.
- S. Malfunctions:
1. Power loss, loss of airflow, clogged air filter, high room temperature, and low room temperature.
 2. High humidity.
 3. Low humidity.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

4. Smoke/fire, water under floor supply fan overload, compressor No. 1, overload compressor No. 1 low pressure.
 5. Compressor No. 1, high pressure.
 6. Compressor No. 2 overload.
 7. Compressor No. 2, low pressure.
 8. Compressor No. 2 high pressure.
 9. Digital Display:
 - a. Control power on.
 - b. Humidifying.
 - c. Dehumidifying
 - d. Compressor No. 1 operating.
 - e. Compressor No. 2 operating.
 - f. Heat operating.
 - g. Economy cooling.
 10. Push buttons shall stop and start process cooling system, silence audible alarm, test indicators, and display room's relative humidity.
- T. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display unit status and alarms via an open protocol BACnet data interface.
- U. Hardwired Points:
1. Monitoring: On-off status, common trouble alarm space temperature space relative humidity.
 2. Control: On-off operation, space temperature set-point adjustment space relative humidity set-point adjustment
- V. Compatible with ASHRAE 135 (BACnet) Industry-accepted, open-protocol for communication interface with the BAS shall enable the DDC or the BAS operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at unit control panel shall be available through the DDC or the BAS.
- 2.2 FLOOR-MOUNTED UNITS 24 KW (7 TONS) AND SMALLER (NOT USED)**
- 2.3 CEILING-MOUNTED UNITS (NOT USED)**
- 2.4 CONSOLE UNITS**
- A. Description: Split system consisting of evaporator section for floor or wall mounting and remote condensing section.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- B. Evaporator Cabinet: Furniture-grade steel with baked-enamel finish; with front access and containing direct-drive centrifugal fans and two-speed motor.
- C. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.
- D. Condenser Cabinet: Steel with baked-enamel finish and containing compressor and condenser.
- E. Compressor: Hermetic scroll, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
- F. Refrigeration Circuit: Filter/dryer, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
- G. Refrigerant: R-410A unless otherwise indicated.
- H. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins.
 - 1. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.
- I. Remote Air-Cooled Refrigerant Condenser: Integral, copper-tube aluminum-fin coil with centrifugal fan, direct driven.
- J. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.
- K. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor and high-temperature-limit switches.
- L. Filter: Disposable, glass-fiber media 25-mm (1-inch) thick.
 - 1. Arrestance: 90 percent according to ASHRAE 52.1.
 - 2. MERV Rating: 7 according to ASHRAE 52.2.
- M. Electrode Steam Humidifier: Self-contained and microprocessor controlled; with replaceable cylinder.
- N. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
- O. Control System: Unit-mounted panel with contactors, control transformer with circuit breaker, and solid-state temperature control modules.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

Wall-mounted control panel shall be solid-state, with start-stop switch and adjustable temperature set point.

P. DDC or BAS Interface: Provide connection to the DDC or the BAS system.

2.5 FAN MOTORS

- A. Default motor characteristics are specified in Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.
- B. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.
- C. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- D. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

2.6 SPECIAL TOOLS

- A. If any part of equipment furnished under these specifications requires a special tool for assembly, adjustment, setting, or maintenance and the tool is not readily available from the commercial tool market, furnish the necessary tools with equipment as a standard accessory.

2.7 CORROSION CONTROL (NOT USED)

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Handle and install refrigeration units and accessories in accordance with the instructions and recommendations of the manufacturer.
- B. Coordinate installation of Computer room Air Conditioning Units with Computer room access flooring installer.
- C. Field Refrigerant Piping: As specified in specification Section 23 23 00, REFRIGERANT PIPING.
- D. Electrical System Connections and Equipment Ground: As specified in Division 26 Sections.

3.2 CONNECTIONS

- A. Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in piping

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

systems. If Drawings are explicit enough, these requirements may be reduced or omitted.

- B. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- C. Install piping adjacent to machine to allow service and maintenance.
- D. Water and Drainage Connections: Comply with applicable requirements in Section 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING and Section 22 11 00, FACILITY WATER DISTRIBUTION. Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.
- E. Retain first paragraph below for units with hot-water coils.
- F. Refrigerant Piping: Comply with applicable requirements in Section 23 23 00, REFRIGERANT PIPING. Provide shutoff valves and piping.

3.3 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. After startup service and performance test, change filters and flush humidifier.

3.4 STARTUP AND TESTING

- A. The CxA will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and CxA. Provide a minimum of 7 days prior notice.
- B. Provide services of manufacturer's technical representative for four hours to instruct VA personnel in operation and maintenance of computer room air conditioning equipment.

3.5 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the CxA.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2
Bancroft Architects + Engineers

03-01-23

- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.6 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for 4 hours to instruct VA personnel in operation and maintenance of units.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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Fargo, VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-01-23

SECTION 23 82 00
CONVECTION HEATING AND COOLING UNITS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. This section specifies room fan-coil units, and unit heaters.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.
- D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
- E. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- F. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- G. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.
- H. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- I. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- J. Section 23 31 00, HVAC DUCTS and CASINGS.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standards will govern.
- B. Air-Conditioning, Heating, and Refrigeration Institute (ANSI/AHRI):
440-2019.....Performance Rating of Fan-Coil Units
- C. National Fire Protection Association (NFPA):
70-2020.....National Electrical Code
90A-2021.....Standard for the Installation of
Air-Conditioning and Ventilating Systems
- D. Underwriters Laboratories, Inc. (UL):
181-2013(R2017).....Standard for Factory-Made Air Ducts and Air
Connectors
1995-2015(R2018).....Heating and Cooling Equipment

Fargo, VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-01-23

1.4 SUBMITTALS

- A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 XX XX, SECTION TITLE", with applicable paragraph identification.
- C. Manufacturer's Literature and Data Including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
 - 1. Unit heaters.
- D. Certificates:
 - 1. Compliance with paragraph QUALITY ASSURANCE.
 - 2. Compliance with specified standards.
- E. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replaceable parts, and troubleshooting guide:
 - 1. Include complete list indicating all components of the systems.
 - 2. Include complete diagrams of the internal wiring for each item of equipment.
 - 3. Diagrams shall have their terminals identified to facilitate installation, operation, and maintenance.
- F. Completed System Readiness Checklists provided by the CxA and completed by the contractor, signed by a qualified technician, and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- G. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 QUALITY ASSURANCE

- A. Refer to paragraph QUALITY ASSURANCE of Section 23 05 11, COMMON WORK RESULTS FOR HVAC. Provide guarantee in accordance with FAR clause 52.246-21.
- B. Bio-Based Materials: For products designated by the USDA's Bio-Preferred Program, provide products that meet or exceed USDA

Fargo, VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-01-23

recommendations for bio-based content, so long as products meet all performance requirements in this specifications section. For more information regarding the product categories covered by the Bio-Preferred Program, visit [http: www.biopreferred.gov](http://www.biopreferred.gov).

C. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.

1.6 AS-BUILT DOCUMENTATION

A. Comply with requirements in paragraph AS-BUILT DOCUMENTATION of Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

PART 2 - PRODUCTS

2.1 INDUCTION UNITS (NOT USED)

2.2 ROOM FAN-COIL UNITS (NOT USED)

2.3 UNIT HEATERS

- A. General: Horizontal or vertical discharge type for electric heating medium, as indicated.
- B. Casing: Steel sheet, phosphatized to resist rust and finished in baked enamel. Provide hanger supports.
- C. Fan: Propeller type, direct driven by manufacturer's standard electric motor. Provide resilient mounting. Provide fan guard for horizontal discharge units.
- D. Discharge Air Control:
 - 1. Horizontal Discharge: Horizontal, adjustable louvers.
 - 2. Vertical Discharge: Radial louver diffuser.
- E. Electric Units: UL listed, factory wired to terminal strips for field connection of power and control wiring.
 - 1. Heating Elements: Nickel chromium alloy resistance wire embedded in a magnesium oxide insulating refractory and sealed in corrosion resisting metallic sheath with fins. Three phase heaters shall have balanced phases.
 - 2. Thermal Cutout: Manual reset type, which disconnects elements, and motor in the event normal operating temperatures are exceeded.
 - 3. Magnetic Contactor: Factory-installed with low voltage relay for remote pilot duty thermostat operation.

Fargo, VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-01-23

- G. Controls: Provide field installed remote wall mounted line voltage electric space thermostats or unit mounted return air thermostats, where shown or specified to control the unit fan.

2.4 CABINET UNIT HEATERS (NOT USED)

2.5 WALL-MOUNTED UNIT HEATERS (NOT USED)

2.6 CONVECTORS (NOT USED)

2.7 FINNED-TUBE RADIATION UNITS (NOT USED)

2.8 RADIANT CEILING PANELS (NOT USED)

PART 3 - EXECUTION

3.1 INSTALLATION

- A. If an installation is unsatisfactory to the COR, the contractor shall correct the installation at no additional cost or time to the Government.
- B. Work shall be installed as shown and according to the manufacturer's diagrams and recommendations.
- C. Handle and install units in accordance with manufacturer's written instructions.
- D. Support units rigidly so they always remain stationary. Cross-bracing or other means of stiffening shall be provided as necessary. Method of support shall be such that distortion and malfunction of units cannot occur.
- E. Install fiberglass blanket insulation with a minimum R value of 8 above hydronic radiant panels.

3.2 STARTUP AND TESTING

- A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.
- B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.
- C. The CxA will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and CxA. Provide a minimum notice of 10 working days prior to startup and testing.

Fargo, VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-01-23

3.3 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- B. Components provided under this section of the specification will be tested as part of a larger system.

3.4 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

- - - E N D - - -

DIVISION 26

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

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01-01-16

SECTION 26 05 11
REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section applies to all sections of Division 26.
- B. Furnish and install electrical systems, materials, equipment, and accessories in accordance with the specifications and drawings. Capacities and ratings of motors, transformers, conductors and cable, switchboards, switchgear, panelboards, motor control centers, generators, automatic transfer switches, and other items and arrangements for the specified items are shown on the drawings.
- C. Electrical service entrance equipment and arrangements for temporary and permanent connections to the electric utility company's system shall conform to the electric utility company's requirements. Coordinate fuses, circuit breakers and relays with the electric utility company's system, and obtain electric utility company approval for sizes and settings of these devices.
- D. Conductor ampacities specified or shown on the drawings are based on copper conductors, with the conduit and raceways sized per NEC. Aluminum conductors are prohibited.

1.2 MINIMUM REQUIREMENTS

- A. The latest International Building Code (IBC), Underwriters Laboratories, Inc. (UL), Institute of Electrical and Electronics Engineers (IEEE), and National Fire Protection Association (NFPA) codes and standards are the minimum requirements for materials and installation.
- B. The drawings and specifications shall govern in those instances where requirements are greater than those stated in the above codes and standards.

1.3 TEST STANDARDS

- A. All materials and equipment shall be listed, labeled, or certified by a Nationally Recognized Testing Laboratory (NRTL) to meet Underwriters Laboratories, Inc. (UL), standards where test standards have been established. Materials and equipment which are not covered by UL standards will be accepted, providing that materials and equipment are

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-16

listed, labeled, certified or otherwise determined to meet the safety requirements of a NRTL. Materials and equipment which no NRTL accepts, certifies, lists, labels, or determines to be safe, will be considered if inspected or tested in accordance with national industrial standards, such as ANSI, NEMA, and NETA. Evidence of compliance shall include certified test reports and definitive shop drawings.

B. Definitions:

1. Listed: Materials and equipment included in a list published by an organization that is acceptable to the Authority Having Jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production or listed materials and equipment or periodic evaluation of services, and whose listing states that the materials and equipment either meets appropriate designated standards or has been tested and found suitable for a specified purpose.
2. Labeled: Materials and equipment to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the Authority Having Jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled materials and equipment, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.
3. Certified: Materials and equipment which:
 - a. Have been tested and found by a NRTL to meet nationally recognized standards or to be safe for use in a specified manner.
 - b. Are periodically inspected by a NRTL.
 - c. Bear a label, tag, or other record of certification.
4. Nationally Recognized Testing Laboratory: Testing laboratory which is recognized and approved by the Secretary of Labor in accordance with OSHA regulations.

1.4 QUALIFICATIONS (PRODUCTS AND SERVICES)

- A. Manufacturer's Qualifications: The manufacturer shall regularly and currently produce, as one of the manufacturer's principal products, the materials and equipment specified for this project, and shall have manufactured the materials and equipment for at least three years.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-16

B. Product Qualification:

1. Manufacturer's materials and equipment shall have been in satisfactory operation, on three installations of similar size and type as this project, for at least three years.
2. The Government reserves the right to require the Contractor to submit a list of installations where the materials and equipment have been in operation before approval.

C. Service Qualifications: There shall be a permanent service organization maintained or trained by the manufacturer which will render satisfactory service to this installation within four hours of receipt of notification that service is needed. Submit name and address of service organizations.

1.5 APPLICABLE PUBLICATIONS

- A. Applicable publications listed in all Sections of Division 26 shall be the latest issue, unless otherwise noted.
- B. Products specified in all sections of Division 26 shall comply with the applicable publications listed in each section.

1.6 MANUFACTURED PRODUCTS

- A. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, and for which replacement parts shall be available. Materials and equipment furnished shall be new, and shall have superior quality and freshness.
- B. When more than one unit of the same class or type of materials and equipment is required, such units shall be the product of a single manufacturer.
- C. Equipment Assemblies and Components:
 1. Components of an assembled unit need not be products of the same manufacturer.
 2. Manufacturers of equipment assemblies, which include components made by others, shall assume complete responsibility for the final assembled unit.
 3. Components shall be compatible with each other and with the total assembly for the intended service.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-16

4. Constituent parts which are similar shall be the product of a single manufacturer.
- D. Factory wiring and terminals shall be identified on the equipment being furnished and on all wiring diagrams.
- E. When Factory Tests are specified, Factory Tests shall be performed in the factory by the equipment manufacturer, and witnessed by the contractor. In addition, the following requirements shall be complied with:
 1. The Government shall have the option of witnessing factory tests. The Contractor shall notify the Government through the COR a minimum of thirty (30) days prior to the manufacturer's performing of the factory tests.
 2. When factory tests are successful, contractor shall furnish four (4) copies of the equipment manufacturer's certified test reports to the COR fourteen (14) days prior to shipment of the equipment, and not more than ninety (90) days after completion of the factory tests.
 3. When factory tests are not successful, factory tests shall be repeated in the factory by the equipment manufacturer, and witnessed by the Contractor. The Contractor shall be liable for all additional expenses for the Government to witness factory re-testing.

1.7 VARIATIONS FROM CONTRACT REQUIREMENTS

- A. Where the Government or the Contractor requests variations from the contract requirements, the connecting work and related components shall include, but not be limited to additions or changes to branch circuits, circuit protective devices, conduits, wire, feeders, controls, panels and installation methods.

1.8 MATERIALS AND EQUIPMENT PROTECTION

- A. Materials and equipment shall be protected during shipment and storage against physical damage, vermin, dirt, corrosive substances, fumes, moisture, cold and rain.
 1. Store materials and equipment indoors in clean dry space with uniform temperature to prevent condensation.
 2. During installation, equipment shall be protected against entry of foreign matter, and be vacuum-cleaned both inside and outside before

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-16

- testing and operating. Compressed air shall not be used to clean equipment. Remove loose packing and flammable materials from inside equipment.
3. Damaged equipment shall be repaired or replaced, as determined by the COR.
 4. Painted surfaces shall be protected with factory installed removable heavy kraft paper, sheet vinyl or equal.
 5. Damaged paint on equipment shall be refinished with the same quality of paint and workmanship as used by the manufacturer so repaired areas are not obvious.

1.9 WORK PERFORMANCE

- A. All electrical work shall comply with requirements of the latest NFPA 70 (NEC), NFPA 70B, NFPA 70E, NFPA 99, NFPA 110, OSHA Part 1910 subpart J - General Environmental Controls, OSHA Part 1910 subpart K - Medical and First Aid, and OSHA Part 1910 subpart S - Electrical, in addition to other references required by contract.
- B. Job site safety and worker safety is the responsibility of the Contractor.
- C. Electrical work shall be accomplished with all affected circuits or equipment de-energized. However, energized electrical work may be performed only for the non-destructive and non-invasive diagnostic testing(s), or when scheduled outage poses an imminent hazard to patient care, safety, or physical security. In such case, all aspects of energized electrical work, such as the availability of appropriate/correct personal protective equipment (PPE) and the use of PPE, shall comply with the latest NFPA 70E, as well as the following requirements:
 1. Only Qualified Person(s) shall perform energized electrical work. Supervisor of Qualified Person(s) shall witness the work of its entirety to ensure compliance with safety requirements and approved work plan.
 2. At least two weeks before initiating any energized electrical work, the Contractor and the Qualified Person(s) who is designated to perform the work shall visually inspect, verify and confirm that the

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-16

- work area and electrical equipment can safely accommodate the work involved.
3. At least two weeks before initiating any energized electrical work, the Contractor shall develop and submit a job specific work plan, and energized electrical work request to the COR, and Medical Center's Chief Engineer or his/her designee. At the minimum, the work plan must include relevant information such as proposed work schedule, area of work, description of work, name(s) of Supervisor and Qualified Person(s) performing the work, equipment to be used, procedures to be used on and near the live electrical equipment, barriers to be installed, safety equipment to be used, and exit pathways.
 4. Energized electrical work shall begin only after the Contractor has obtained written approval of the work plan, and the energized electrical work request from the COR, and Medical Center's Chief Engineer or his/her designee. The Contractor shall make these approved documents present and available at the time and place of energized electrical work.
 5. Energized electrical work shall begin only after the Contractor has invited and received acknowledgment from the COR, and Medical Center's Chief Engineer or his/her designee to witness the work.
- D. For work that affects existing electrical systems, arrange, phase and perform work to assure minimal interference with normal functioning of the facility. Refer to Article OPERATIONS AND STORAGE AREAS under Section 01 00 00, GENERAL REQUIREMENTS.
- E. New work shall be installed and connected to existing work neatly, safely and professionally. Disturbed or damaged work shall be replaced or repaired to its prior conditions, as required by Section 01 00 00, GENERAL REQUIREMENTS.
- F. Coordinate location of equipment and conduit with other trades to minimize interference.

1.10 EQUIPMENT INSTALLATION AND REQUIREMENTS

- A. Equipment location shall be as close as practical to locations shown on the drawings.
- B. Working clearances shall not be less than specified in the NEC.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-16

C. Inaccessible Equipment:

1. Where the Government determines that the Contractor has installed equipment not readily accessible for operation and maintenance, the equipment shall be removed and reinstalled as directed at no additional cost to the Government.
2. "Readily accessible" is defined as being capable of being reached quickly for operation, maintenance, or inspections without the use of ladders, or without climbing or crawling under or over obstacles such as, but not limited to, motors, pumps, belt guards, transformers, piping, ductwork, conduit and raceways.

- D. Electrical service entrance equipment and arrangements for temporary and permanent connections to the electric utility company's system shall conform to the electric utility company's requirements. Coordinate fuses, circuit breakers and relays with the electric utility company's system, and obtain electric utility company approval for sizes and settings of these devices.

1.11 EQUIPMENT IDENTIFICATION

- A. In addition to the requirements of the NEC, install an identification sign which clearly indicates information required for use and maintenance of items such as switchboards and switchgear, panelboards, cabinets, motor controllers, fused and non-fused safety switches, generators, automatic transfer switches, separately enclosed circuit breakers, individual breakers and controllers in switchboards, switchgear and motor control assemblies, control devices and other significant equipment.
- B. Identification signs for Normal Power System equipment shall be laminated black phenolic resin with a white core with engraved lettering. Identification signs for Essential Electrical System (EES) equipment, as defined in the NEC, shall be laminated red phenolic resin with a white core with engraved lettering. Lettering shall be a minimum of 12 mm (1/2 inch) high. Identification signs shall indicate equipment designation, rated bus amperage, voltage, number of phases, number of wires, and type of EES power branch as applicable. Secure nameplates with screws.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-16

- C. Install adhesive arc flash warning labels on all equipment as required by the latest NFPA 70E. Label shall show specific and correct information for specific equipment based on its arc flash calculations. Label shall show the followings:
1. Nominal system voltage.
 2. Equipment/bus name, date prepared, and manufacturer name and address.
 3. Arc flash boundary.
 4. Available arc flash incident energy and the corresponding working distance.
 5. Minimum arc rating of clothing.
 6. Site-specific level of PPE.

1.12 SUBMITTALS

- A. Submit to the COR in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. The Government's approval shall be obtained for all materials and equipment before delivery to the job site. Delivery, storage or installation of materials and equipment which has not had prior approval will not be permitted.
- C. All submittals shall include six copies of adequate descriptive literature, catalog cuts, shop drawings, test reports, certifications, samples, and other data necessary for the Government to ascertain that the proposed materials and equipment comply with drawing and specification requirements. Catalog cuts submitted for approval shall be legible and clearly identify specific materials and equipment being submitted.
- D. Submittals for individual systems and equipment assemblies which consist of more than one item or component shall be made for the system or assembly as a whole. Partial submittals will not be considered for approval.
1. Mark the submittals, "SUBMITTED UNDER SECTION _____".
 2. Submittals shall be marked to show specification reference including the section and paragraph numbers.
 3. Submit each section separately.
- E. The submittals shall include the following:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-16

1. Information that confirms compliance with contract requirements.
Include the manufacturer's name, model or catalog numbers, catalog information, technical data sheets, shop drawings, manuals, pictures, nameplate data, and test reports as required.
3. Elementary and interconnection wiring diagrams for communication and signal systems, control systems, and equipment assemblies. All terminal points and wiring shall be identified on wiring diagrams.
4. Parts list which shall include information for replacement parts and ordering instructions, as recommended by the equipment manufacturer.

F. Maintenance and Operation Manuals:

1. Submit as required for systems and equipment specified in the technical sections. Furnish in hardcover binders or an approved equivalent.
2. Inscribe the following identification on the cover: the words "MAINTENANCE AND OPERATION MANUAL," the name and location of the system, material, equipment, building, name of Contractor, and contract name and number. Include in the manual the names, addresses, and telephone numbers of each subcontractor installing the system or equipment and the local representatives for the material or equipment.
3. Provide a table of contents and assemble the manual to conform to the table of contents, with tab sheets placed before instructions covering the subject. The instructions shall be legible and easily read, with large sheets of drawings folded in.
4. The manuals shall include:
 - a. Internal and interconnecting wiring and control diagrams with data to explain detailed operation and control of the equipment.
 - b. A control sequence describing start-up, operation, and shutdown.
 - c. Description of the function of each principal item of equipment.
 - d. Installation instructions.
 - e. Safety precautions for operation and maintenance.
 - f. Diagrams and illustrations.
 - g. Periodic maintenance and testing procedures and frequencies, including replacement parts numbers.
 - h. Performance data.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-16

- i. Pictorial "exploded" parts list with part numbers. Emphasis shall be placed on the use of special tools and instruments. The list shall indicate sources of supply, recommended spare and replacement parts, and name of servicing organization.
 - j. List of factory approved or qualified permanent servicing organizations for equipment repair and periodic testing and maintenance, including addresses and factory certification qualifications.
- G. Approvals will be based on complete submission of shop drawings, manuals, test reports, certifications, and samples as applicable.
- H. After approval and prior to installation, furnish the COR with one sample of each of the following:
- 1. A minimum 300 mm (12 inches) length of each type and size of wire and cable along with the tag from the coils or reels from which the sample was taken. The length of the sample shall be sufficient to show all markings provided by the manufacturer.
 - 2. Each type of conduit coupling, bushing, and termination fitting.
 - 3. Conduit hangers, clamps, and supports.
 - 4. Duct sealing compound.
 - 5. Each type of receptacle, toggle switch, lighting control sensor, outlet box, manual motor starter, device wall plate, engraved nameplate, wire and cable splicing and terminating material, and branch circuit single pole molded case circuit breaker.

1.13 SINGULAR NUMBER

- A. Where any device or part of equipment is referred to in these specifications in the singular number (e.g., "the switch"), this reference shall be deemed to apply to as many such devices as are required to complete the installation as shown on the drawings.

1.15 ACCEPTANCE CHECKS AND TESTS

- A. The Contractor shall furnish the instruments, materials, and labor for tests.
- B. Where systems are comprised of components specified in more than one section of Division 26, the Contractor shall coordinate the installation, testing, and adjustment of all components between various

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-16

manufacturer's representatives and technicians so that a complete, functional, and operational system is delivered to the Government.

- C. When test results indicate any defects, the Contractor shall repair or replace the defective materials or equipment, and repeat the tests for the equipment. Repair, replacement, and re-testing shall be accomplished at no additional cost to the Government.

1.16 WARRANTY

- A. All work performed and all equipment and material furnished under this Division shall be free from defects and shall remain so for a period of one year from the date of acceptance of the entire installation by the Contracting Officer for the Government.

1.17 INSTRUCTION

- A. Instruction to designated Government personnel shall be provided for the particular equipment or system as required in each associated technical specification section.
- B. Furnish the services of competent and factory-trained instructors to give full instruction in the adjustment, operation, and maintenance of the specified equipment and system, including pertinent safety requirements. Instructors shall be thoroughly familiar with all aspects of the installation, and shall be factory-trained in operating theory as well as practical operation and maintenance procedures.
- C. A training schedule shall be developed and submitted by the Contractor and approved by the COR at least 30 days prior to the planned training.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

---END---

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

SECTION 26 05 13
MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, and connection of medium-voltage cables, indicated as cable or cables in this section, and medium-voltage cable splices and terminations.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- B. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- C. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits for medium-voltage cables.
- D. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Manholes and ducts for medium-voltage cables.
- E. Section 26 12 19, PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS: Medium-voltage cable terminations for use in pad-mounted, liquid-filled, medium-voltage transformers.

1.3 QUALITY ASSURANCE

- A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

- A. Factory Tests shall be required.
- B. Factory Tests shall be in accordance with Paragraph, MANUFACTURED PRODUCTS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirement:
1. A representative sample of Medium-voltage cables from each lot shall be factory tested per NEMA WC 74 to ensure that there are no electrical defects in that specific lot of cable.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

1.5 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:

- a. Submit sufficient information to demonstrate compliance with drawings and specifications.
- b. Submit the following data for approval:
 - 1) Complete electrical ratings.
 - 2) Installation instructions.

2. Samples:

- a. After approval of submittal and prior to installation, Contractor shall furnish sample in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

3. Certifications:

- a. Factory Test Reports: Submit certified factory production test reports for approval.
- b. Field Test Reports: Submit field test reports for approval.
- c. Compatibility: Submit a certificate from the cable manufacturer that the splices and terminations are approved for use with the cable.
- d. Two weeks prior to final inspection, submit the following.
 - 1) Certification by the manufacturer that the cables, splices, and terminations conform to the requirements of the drawings and specifications.
 - 2) Certification by the Contractor that the cables, splices, and terminations have been properly installed and tested.
 - 3) Certification by the Contractor that each splice and each termination were completely installed in a single continuous work period by a single qualified worker without any overnight interruption.

4. Qualified Worker Approval:

- a. Qualified workers who install cables, splices, and terminations shall have a minimum of five years of experience splicing and terminating cables, including experience with the materials in the approved splices and terminations. Qualified workers who

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

perform cable testing shall have a minimum of five year of experience performing electrical testing of medium-voltage cables, including the ability to understand, interpret test results and develop test report.

- b. Furnish satisfactory proof of such experience for each qualified worker who splices or terminates the cables.

1.6 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American Society for Testing and Materials (ASTM):

B3-13(2018).....Standard Specification for Soft or Annealed
Copper Wire

C. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

48-20.....Test Procedures and Requirements for
Alternating-Current Cable Terminations Used on
Shielded Cables Having Laminated Insulation
Rated 2.5 kV through 765 kV or Extruded
Insulation Rated 2.5 kV through 500 kV

386-16.....Separable Insulated Connector Systems for Power
Distribution Systems above 600 V

400-12.....Guide for Field Testing and Evaluation of the
Insulation of Shielded Power Cable Systems

400.2-13.....Guide for Field Testing of Shielded Power Cable
Systems Using Very Low Frequency (VLF)

404-12.....Extruded and Laminated Dielectric Shielded
Cable Joints Rated 2500 V to 500,000 V

D. National Electrical Manufacturers Association (NEMA):

WC 71-14.....Non-Shielded Cables Rated 2001-5000 Volts for
Use in the Distribution of Electric Energy

WC 74-17.....5-46 KV Shielded Power Cable for Use in the
Transmission and Distribution of Electric
Energy

E. National Fire Protection Association (NFPA):

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

70-23.....National Electrical Code (NEC)

F. Underwriters Laboratories (UL):

1072-06 Medium-Voltage Power Cables

1.7 SHIPMENT AND STORAGE

- A. Cable shall be shipped on reels such that it is protected against physical, mechanical and environmental damage. Each end of each length of cable shall be hermetically sealed with manufacturer's end caps and securely attached to the reel.
- B. Cable stored and/or cut on site shall have the ends turned down, and sealed with cable manufacturer's standard cable end seals, or field-installed heat-shrink cable end seals.

PART 2 - PRODUCTS

2.1 CABLE

- A. Cable shall be in accordance with ASTM, IEEE, NEC, NEMA and UL, and as shown on the drawings.
- B. Single conductor stranded copper conforming to ASTM B3.
- C. Voltage Rating:
 - 2. 15,000 V cable shall be used on all distribution systems with voltages ranging from 5,000 V to 15,000 V.
- D. Insulation:
 - 1. Insulation level shall be 133%.
 - 2. Types of insulation:
 - a. Cable type abbreviation, EPR: Ethylene propylene rubber insulation shall be thermosetting, light and heat stabilized.
 - b. Cable type abbreviation, XLP, XLPE, or TR-XLPE: cross-linked polyethylene insulation shall be thermosetting, light and heat stabilized, and chemically cross-linked.
- E. Insulation shield shall be semi-conducting. Conductor shield shall be semi-conducting.
- F. Insulation shall be wrapped with copper shielding tape, helically-applied over semi-conducting insulation shield.
- G. Heavy duty, overall protective polyvinyl chloride jacket shall enclose every cable. The manufacturer's name, cable type and size, and other pertinent information shall be marked or molded clearly on the overall protective jacket.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

- H. Cable temperature ratings for continuous operation, emergency overload operation, and short circuit operation shall be not less than the NEC, NEMA WC 71, or NEMA WC 74 standard for the respective cable.

2.2 SPLICES AND TERMINATIONS

- A. Materials shall be compatible with the cables being spliced and terminated, and shall be suitable for the prevailing environmental conditions.
- B. In locations where moisture might be present, the splices shall be watertight. In manholes and pullboxes, the splices shall be submersible.
- C. Splices:
1. Shall comply with IEEE 404. Include all components required for complete splice, with detailed instructions.
- D. Terminations:
1. Shall comply with IEEE 48. Include shield ground strap for shielded cable terminations.
 4. Class 3 terminations for outdoor use: Kit with stress cone and compression-type connector.
 6. Dead-break terminations for indoor and outdoor use: 600 A deadbreak premolded rubber elbow connectors with bushing inserts, suitable for submersible applications. Separable connectors shall comply with the requirements of IEEE 386, and shall be interchangeable between suppliers. Allow sufficient slack in medium-voltage cable, ground, and drain wires to permit elbow connectors to be moved to their respective parking stands.
 7. Ground metallic cable shields with a device designed for that purpose, consisting of a solderless connector enclosed in watertight rubber housing covering the entire assembly.
 8. Provide insulated cable supports to relieve any strain imposed by cable weight or movement. Ground cable supports to the grounding system.

2.3 FIREPROOFING TAPE

- A. Fireproofing tape shall be flexible, non-corrosive, self-extinguishing, arcproof, and fireproof intumescent elastomer. Securing tape shall be

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

glass cloth electrical tape not less than 0.18 mm (7 mils) thick, and
19 mm (0.75 inch) wide.

PART 3 - EXECUTION

3.1 GENERAL

- A. Installation shall be in accordance with the NEC, as shown on the drawings, and manufacturer's instructions.
- B. Cable shall be installed in conduit above grade and duct bank below grade.
- C. All cables of a feeder shall be pulled simultaneously.
- D. Conductors of different systems (e.g., 5kV and 15kV) shall not be installed in the same raceway.
- E. Splice the cables only in manholes and pullboxes.
- F. Ground shields in accordance with Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- G. Cable maximum pull length, maximum pulling tension, and minimum bend radius shall conform with the recommendations of the manufacturer.
- H. Use suitable lubricating compounds on the cables to prevent pulling damage. Provide compounds that are not injurious to the cable jacket and do not harden or become adhesive.
- I. Seal the cable ends prior to pulling, to prevent the entry of moisture or lubricant.

3.2 PROTECTION DURING SPLICING OPERATIONS

- A. Blowers shall be provided to force fresh air into manholes where free movement or circulation of air is obstructed. Waterproof protective coverings shall be available on the work site to provide protection against moisture while a splice is being made. Pumps shall be used to keep manholes dry during splicing operations. Under no conditions shall a splice or termination be made that exposes the interior of a cable to moisture. A manhole ring at least 150 mm (6 inches) above ground shall be used around the manhole entrance to keep surface water from entering the manhole. Unused ducts shall be plugged and water seepage through ducts in use shall be stopped before splicing.

3.3 PULLING CABLES IN DUCTS AND MANHOLES

- A. Cables shall be pulled into ducts with equipment designed for this purpose, including power-driven winches, cable-feeding flexible tube

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

guides, cable grips, pulling eyes, and lubricants. A sufficient number of qualified workers and equipment shall be employed to ensure the careful and proper installation of the cable.

- B. Cable reels shall be set up at the side of the manhole opening and above the duct or hatch level, allowing cables to enter through the opening without reverse bending. Flexible tube guides shall be installed through the opening in a manner that will prevent cables from rubbing on the edges of any structural member.
- C. Cable shall be unreeled from the top of the reel. Pay-out shall be carefully controlled. Cables to be pulled shall be attached through a swivel to the main pulling wire by means of a suitable cable grip and pulling eye.
- D. Woven-wire cable grips shall be used to grip the cable end when pulling small cables and short straight lengths of heavier cables.
- E. Pulling eyes shall be attached to the cable conductors to prevent damage to the cable structure.
- F. Cables shall be liberally coated with a suitable lubricant as they enter the tube guide or duct. Rollers, sheaves, or tube guides around which the cable is pulled shall conform to the minimum bending radius of the cable.
- G. Cables shall be pulled into ducts at a reasonable speed. Cable pulling using a vehicle shall not be permitted. Pulling operations shall be stopped immediately at any indication of binding or obstruction, and shall not be resumed until the potential for damage to the cable is corrected. Sufficient slack shall be provided for free movement of cable due to expansion or contraction.
- H. Splices in manholes shall be firmly supported on cable racks. Cable ends shall overlap at the ends of a section to provide sufficient undamaged cable for splicing.
- I. Cables cut in the field shall have the cut ends immediately sealed to prevent entrance of moisture.

3.4 SPLICES AND TERMINATIONS

- A. Install the materials as recommended by the manufacturer, including precautions pertaining to air temperature and humidity during installation.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

- B. Installation shall be executed by qualified person trained to perform medium-voltage equipment installations. Tools shall be as recommended or provided by the manufacturer. Installation shall comply with manufacturer's instructions.
- C. Splices in manholes shall be located midway between cable racks on walls of manholes, and supported with cable arms at approximately the same elevation as the enclosing duct.
- D. Where the Government determines that unsatisfactory splices and terminations have been installed, the Contractor shall replace the unsatisfactory splices and terminations with approved material at no additional cost to the Government.

3.5 FIREPROOFING

- A. Cover all cable segments exposed in manholes and pullboxes with fireproofing tape.
- B. Apply the tape in a single layer, wrapped in a half-lap manner, or as recommended by the manufacturer. Extend the tape not less than 25 mm (1 inch) into each duct.
- C. At each end of a taped cable section, secure the fireproof tape in place with glass cloth tape.

3.6 CIRCUIT IDENTIFICATION OF FEEDERS

- A. In each manhole and pullbox, install permanent identification tags on each circuit's cables to clearly designate the circuit identification and voltage. The tags shall be the embossed brass type, 40 mm (1.5 inches) in diameter and 40 mils thick. Attach tags with plastic ties. Position the tags so they will be easy and clear to read after the fireproofing tape is installed.

3.7 ACCEPTANCE CHECKS AND TESTS

- A. General:
 - 1. Perform tests in accordance with the latest IEEE 400 and 400.2, manufacturer's recommendations, and as specified in this specification.
 - 2. Contractor shall make arrangements to have tests witnessed by the COR. Contractor shall proceed with tests only after obtaining approval from the COR.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

- B. Visual Inspection: Perform visual inspection prior to electrical tests.
1. Inspect exposed sections of cables for physical damage.
 2. Inspect shield grounding, cable supports, splices, and terminations.
 3. Verify that visible cable bends meet manufacturer's minimum bending radius requirement.
 4. Verify installation of fireproofing tape and identification tags.
 5. At the time of final acceptance, Contractor shall provide the COR visual field inspection notes, findings, and photographs detailing accessible inspection locations.
- C. Electrical Tests - New Cables: Perform preparation and tests in order shown below:
1. Preparation Prior to Testing: Splices and terminations applied to new cables shall be completed prior to testing. For renovation installation, ends of new cables intended to be spliced to existing service-aged cables shall be prepared (cut back) to allow testing without flashover or tracking. Cables shall not be connected to other equipment while under test.
 2. Perform Insulation-Resistance Test. Test all cables with respect to ground and adjacent cables. All adjacent cables shall be grounded during testing.
 - a. Apply test voltage for a period sufficient to stabilize output voltage and insulation resistance measurement.
 - b. Test data shall include megohm, applied test voltage, and leakage current readings.
 - c. Further testing shall not continue unless the insulation resistance test results meet or exceed the values listed below. Test voltages and minimum acceptable resistance values shall be:

Voltage Class	Test Voltage	Min. Insulation Resistance
5kV	2,500 VDC	1,000 megohms
15kV	2,500 VDC	5,000 megohms
25kV	5,000 VDC	20,000 megohms
35kV	15,000 VDC	100,000 megohms
 3. Perform Tan Delta test. Review test readings with the COR prior to proceeding with the Very Low Frequency (VLF) Withstand test

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

4. Perform Very Low Frequency (VLF) Withstand test. Utilize test voltages in accordance with IEEE 400.2.
- F. Field Test Report: Submit a field test report to the COR that includes the following information:
 1. Project Name, Location, Test Date.
 2. Name of Technician and Company performing the test.
 3. Ambient temperature and humidity at time of test.
 4. Name, Model Number and Description of Test Equipment used.
 5. Circuit identification, cable length, cable type and size, insulation type, cable manufacturer, service age (if any), voltage rating, description of splices or terminations.
 6. Visual field inspection notes, findings, and photographs.
 7. Insulation Resistance Test results:
 - a. Test voltage.
 - b. Measurement in Megohms.
 - c. Leakage current.
 8. Tan Delta results:
 - a. Test voltage.
 - b. Waveform (sinusoidal or cosine-rectangular).
 - c. Mean Tan Delta at V_0 .
 - d. Stability measured by Standard Deviation at V_0 .
 - e. Differential Tan Delta.
 - f. IEEE Condition Assessment Rating.
 9. VLF Withstand results:
 - a. Test voltage.
 - b. Waveform (sinusoidal or cosine-rectangular).
 - c. Pass/Fail Rating.
 10. Conclusions. If any deficiency is discovered based on test results, provide recommendations for corrective action.
- G. Final Acceptance: Final acceptance shall depend upon the satisfactory performance of the cables under test. No cable shall be put into service until all tests are successfully passed, and field test reports have been approved by the COR.

---END---

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of the electrical conductors and cables for use in electrical systems rated 600 V and below, indicated as cable(s), conductor(s), wire, or wiring in this section.

1.2 RELATED WORK

- A. Section 07 84 00, FIRESTOPPING: Sealing around penetrations to maintain the integrity of fire-resistant rated construction.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits for conductors and cables.
- E. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Installation of conductors and cables in manholes and ducts.

1.3 QUALITY ASSURANCE

- A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:
1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Submit the following data for approval:
 - 1) Electrical ratings and insulation type for each conductor and cable.
 - 2) Splicing materials and pulling lubricant.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

2. Certifications: Two weeks prior to final inspection, submit the following.

- a. Certification by the manufacturer that the conductors and cables conform to the requirements of the drawings and specifications.
- b. Certification by the Contractor that the conductors and cables have been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are reference in the text by designation only.

B. American Society of Testing Material (ASTM):

D2301-10.....Standard Specification for Vinyl Chloride
Plastic Pressure-Sensitive Electrical
Insulating Tape

D2304-10.....Test Method for Thermal Endurance of Rigid
Electrical Insulating Materials

D3005-10.....Low-Temperature Resistant Vinyl Chloride
Plastic Pressure-Sensitive Electrical
Insulating Tape

C. National Electrical Manufacturers Association (NEMA):

WC 70-09.....Power Cables Rated 2000 Volts or Less for the
Distribution of Electrical Energy

D. National Fire Protection Association (NFPA):

70-17.....National Electrical Code (NEC)

E. Underwriters Laboratories, Inc. (UL):

44-14.....Thermoset-Insulated Wires and Cables

83-14.....Thermoplastic-Insulated Wires and Cables

467-13.....Grounding and Bonding Equipment

486A-486B-13.....Wire Connectors

486C-13.....Splicing Wire Connectors

486D-15.....Sealed Wire Connector Systems

486E-15.....Equipment Wiring Terminals for Use with
Aluminum and/or Copper Conductors

493-07.....Thermoplastic-Insulated Underground Feeder and
Branch Circuit Cables

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

514B-12.....Conduit, Tubing, and Cable Fittings

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Conductors and cables shall be in accordance with ASTM, NEMA, NFPA, UL, as specified herein, and as shown on the drawings.

B. All conductors shall be copper.

C. Single Conductor and Cable:

1. No. 12 AWG: Minimum size, except where smaller sizes are specified herein or shown on the drawings.

2. No. 8 AWG and larger: Stranded.

3. No. 10 AWG and smaller: Solid; except shall be stranded for final connection to motors, transformers, and vibrating equipment.

4. Insulation: THHN-THWN and XHHW-2. XHHW-2 shall be used for isolated power systems.

E. Color Code:

1. No. 10 AWG and smaller: Solid color insulation or solid color coating.

2. No. 8 AWG and larger: Color-coded using one of the following methods:

a. Solid color insulation or solid color coating.

b. Stripes, bands, or hash marks of color specified.

c. Color using 19 mm (0.75 inches) wide tape.

4. For modifications and additions to existing wiring systems, color coding shall conform to the existing wiring system.

5. Conductors shall be color-coded as follows:

208/120 V	Phase	480/277 V
Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	Gray *
* or white with colored (other than green) tracer.		

6. Lighting circuit "switch legs", and 3-way and 4-way switch "traveling wires," shall have color coding that is unique and

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

distinct (e.g., pink and purple) from the color coding indicated above. The unique color codes shall be solid and in accordance with the NEC. Coordinate color coding in the field with the COR.

7. Color code for isolated power system wiring shall be in accordance with the NEC.

2.2 SPLICES

- A. Splices shall be in accordance with NEC and UL.
- B. Above Ground Splices for No. 10 AWG and Smaller:
 1. Solderless, screw-on, reusable pressure cable type, with integral insulation, approved for copper and aluminum conductors.
 2. The integral insulator shall have a skirt to completely cover the stripped conductors.
 3. The number, size, and combination of conductors used with the connector, as listed on the manufacturer's packaging, shall be strictly followed.
- C. Above Ground Splices for No. 8 AWG to No. 4/0 AWG:
 1. Compression, hex screw, or bolt clamp-type of high conductivity and corrosion-resistant material, listed for use with copper and aluminum conductors.
 2. Insulate with materials approved for the particular use, location, voltage, and temperature. Insulation level shall be not less than the insulation level of the conductors being joined.
 3. Splice and insulation shall be product of the same manufacturer.
 4. All bolts, nuts, and washers used with splices shall be cadmium-plated steel.
- D. Above Ground Splices for 250 kcmil and Larger:
 1. Long barrel "butt-splice" or "sleeve" type compression connectors, with minimum of two compression indents per wire, listed for use with copper and aluminum conductors.
 2. Insulate with materials approved for the particular use, location, voltage, and temperature. Insulation level shall be not less than the insulation level of the conductors being joined.
 3. Splice and insulation shall be product of the same manufacturer.
- E. Underground Splices for No. 10 AWG and Smaller: NOT USED

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

2.3 CONNECTORS AND TERMINATIONS

- A. Mechanical type of high conductivity and corrosion-resistant material, listed for use with copper and aluminum conductors.
- B. Long barrel compression type of high conductivity and corrosion-resistant material, with minimum of two compression indents per wire, listed for use with copper and aluminum conductors.
- C. All bolts, nuts, and washers used to connect connections and terminations to bus bars or other termination points shall be cadmium-plated steel.

2.4 CONTROL WIRING

- A. Unless otherwise specified elsewhere in these specifications, control wiring shall be as specified herein, except that the minimum size shall be not less than No. 14 AWG.
- B. Control wiring shall be sized such that the voltage drop under in-rush conditions does not adversely affect operation of the controls.

2.5 WIRE LUBRICATING COMPOUND

- A. Lubricating compound shall be suitable for the wire insulation and conduit, and shall not harden or become adhesive.
- B. Shall not be used on conductors for isolated power systems.

PART 3 - EXECUTION

3.1 GENERAL

- A. Installation shall be in accordance with the NEC, as shown on the drawings, and manufacturer's instructions.
- B. Install all conductors in raceway systems.
- C. Splice conductors only in outlet boxes, junction boxes, pullboxes, manholes, or handholes.
- D. Conductors of different systems (e.g., 120 V and 277 V) shall not be installed in the same raceway.
- E. Install cable supports for all vertical feeders in accordance with the NEC. Provide split wedge type which firmly clamps each individual cable and tightens due to cable weight.
- F. In panelboards, cabinets, wireways, switches, enclosures, and equipment assemblies, neatly form, train, and tie the conductors with non-metallic ties.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

- G. For connections to motors, transformers, and vibrating equipment, stranded conductors shall be used only from the last fixed point of connection to the motors, transformers, or vibrating equipment.
- H. Use expanding foam or non-hardening duct-seal to seal conduits entering a building, after installation of conductors.
- I. Conductor and Cable Pulling:
 - 1. Provide installation equipment that will prevent the cutting or abrasion of insulation during pulling. Use lubricants approved for the cable.
 - 2. Use nonmetallic pull ropes.
 - 3. Attach pull ropes by means of either woven basket grips or pulling eyes attached directly to the conductors.
 - 4. All conductors in a single conduit shall be pulled simultaneously.
 - 5. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- J. No more than three branch circuits shall be installed in any one conduit.
- K. When stripping stranded conductors, use a tool that does not damage the conductor or remove conductor strands.

3.2 INSTALLATION IN MANHOLES NOT USED SEE 26 05 13 FOR MEDIUM VOLTAGE CABLES

3.3 SPLICE AND TERMINATION INSTALLATION

- A. Splices and terminations shall be mechanically and electrically secure, and tightened to manufacturer's published torque values using a torque screwdriver or wrench.
- B. Where the Government determines that unsatisfactory splices or terminations have been installed, replace the splices or terminations at no additional cost to the Government.

3.4 CONDUCTOR IDENTIFICATION

- A. When using colored tape to identify phase, neutral, and ground conductors larger than No. 8 AWG, apply tape in half-overlapping turns for a minimum of 75 mm (3 inches) from terminal points, and in junction boxes, pullboxes, and manholes. Apply the last two laps of tape with no tension to prevent possible unwinding. Where cable markings are covered by tape, apply tags to cable, stating size and insulation type.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

3.5 FEEDER CONDUCTOR IDENTIFICATION

- A. In each interior pullbox and each underground manhole and handhole, install brass tags on all feeder conductors to clearly designate their circuit identification and voltage. The tags shall be the embossed type, 40 mm (1-1/2 inches) in diameter and 40 mils thick. Attach tags with plastic ties.

3.6 EXISTING CONDUCTORS

- A. Unless specifically indicated on the plans, existing conductors shall not be reused.

3.7 CONTROL WIRING INSTALLATION

- A. Unless otherwise specified in other sections, install control wiring and connect to equipment to perform the required functions as specified or as shown on the drawings.
- B. Install a separate power supply circuit for each system, except where otherwise shown on the drawings.

3.8 CONTROL WIRING IDENTIFICATION

- A. Install a permanent wire marker on each wire at each termination.
- B. Identifying numbers and letters on the wire markers shall correspond to those on the wiring diagrams used for installing the systems.
- C. Wire markers shall retain their markings after cleaning.

3.9 DIRECT BURIAL CABLE INSTALLATION NOT USED

3.10 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:
 - 1. Visual Inspection and Tests: Inspect physical condition.
 - 2. Electrical tests:
 - a. After installation but before connection to utilization devices, such as fixtures, motors, or appliances, test conductors phase-to-phase and phase-to-ground resistance with an insulation resistance tester. Existing conductors to be reused shall also be tested.
 - b. Applied voltage shall be 500 V DC for 300 V rated cable, and 1000 V DC for 600 V rated cable. Apply test for one minute or until reading is constant for 15 seconds, whichever is longer. Minimum

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

insulation resistance values shall not be less than 25 megohms
for 300 V rated cable and 100 megohms for 600 V rated cable.

c. Perform phase rotation test on all three-phase circuits.

---END---

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

26 05 19 - 8

Low-Voltage Electrical Power Conductors and Cables

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01-01-17

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of grounding and bonding equipment, indicated as grounding equipment in this section.
- B. "Grounding electrode system" refers to grounding electrode conductors and all electrodes required or allowed by NEC, as well as made, supplementary, and lightning protection system grounding electrodes.
- C. The terms "connect" and "bond" are used interchangeably in this section and have the same meaning.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.
- C. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduit and boxes.
- D. Section 26 12 19, PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS: pad-mounted, liquid-filled, medium-voltage transformers.
- E. Section 26 13 13, MEDIUM-VOLTAGE CIRCUIT BREAKER SWITCHGEAR: Medium-voltage circuit breaker switchgear.
- F. Section 26 23 13, GENERATOR PARALLELING CONTROLS: Generator paralleling controls.
- G. Section 26 13 16, MEDIUM-VOLTAGE FUSIBLE INTERRUPTER SWITCHES: Medium-voltage fusible interrupter switches.
- H. Section 26 22 00, LOW-VOLTAGE TRANSFORMERS: Low-voltage transformers.
- I. Section 26 23 00, LOW-VOLTAGE SWITCHGEAR: Low-voltage switchgear.
- J. Section 26 24 13, DISTRIBUTION SWITCHBOARDS: Low-voltage distribution switchboards.
- K. Section 26 24 16, PANELBOARDS: Low-voltage panelboards.
- L. Section 26 24 19, MOTOR CONTROL CENTERS: Motor control centers.
- M. Section 26 32 13, ENGINE GENERATORS: Engine generators.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

1.3 QUALITY ASSURANCE

- A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:
1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Submit plans showing the location of system grounding electrodes and connections, and the routing of aboveground and underground grounding electrode conductors.
 2. Test Reports:
 - a. Two weeks prior to the final inspection, submit ground resistance field test reports to the COR.
 3. Certifications:
 - a. Certification by the Contractor that the grounding equipment has been properly installed and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. American Society for Testing and Materials (ASTM):
- B1-13.....Standard Specification for Hard-Drawn Copper Wire
- B3-13.....Standard Specification for Soft or Annealed Copper Wire
- B8-11.....Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
- C. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

81-12.....IEEE Guide for Measuring Earth Resistivity,
Ground Impedance, and Earth Surface Potentials
of a Ground System Part 1: Normal Measurements

D. National Fire Protection Association (NFPA):

70-17.....National Electrical Code (NEC)

70E-15.....National Electrical Safety Code

99-15.....Health Care Facilities

E. Underwriters Laboratories, Inc. (UL):

44-14 Thermoset-Insulated Wires and Cables

83-14 Thermoplastic-Insulated Wires and Cables

467-13 Grounding and Bonding Equipment

PART 2 - PRODUCTS

2.1 GROUNDING AND BONDING CONDUCTORS

- A. Equipment grounding conductors shall be insulated stranded copper, except that sizes No. 10 AWG and smaller shall be solid copper. Insulation color shall be continuous green for all equipment grounding conductors, except that wire sizes No. 4 AWG and larger shall be identified per NEC.
- B. Bonding conductors shall be bare stranded copper, except that sizes No. 10 AWG and smaller shall be bare solid copper. Bonding conductors shall be stranded for final connection to motors, transformers, and vibrating equipment.
- C. Conductor sizes shall not be less than shown on the drawings, or not less than required by the NEC, whichever is greater.
- D. Insulation: THHN-THWN and XHHW-2. XHHW-2 shall be used for isolated power systems.

2.2 GROUND RODS

- A. Copper clad steel 19 mm (0.75 inch) diameter by 3 M (10 feet) long.
- B. Quantity of rods shall be as shown on the drawings, and as required to obtain the specified ground resistance.

2.3 CONCRETE ENCASED ELECTRODE

- A. Concrete encased electrode shall be No. 4 AWG bare copper wire, installed per NEC.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

2.4 GROUND CONNECTIONS

- A. Below Grade and Inaccessible Locations: Exothermic-welded type connectors.
- B. Above Grade:
 - 1. Bonding Jumpers: Listed for use with aluminum and copper conductors. For wire sizes No. 8 AWG and larger, use compression-type connectors. For wire sizes smaller than No. 8 AWG, use mechanical type lugs. Connectors or lugs shall use cadmium-plated steel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.
 - 2. Connection to Building Steel: Exothermic-welded type connectors.
 - 3. Connection to Grounding Bus Bars: Listed for use with aluminum and copper conductors. Use mechanical type lugs, with cadmium-plated steel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.
 - 4. Connection to Equipment Rack and Cabinet Ground Bars: Listed for use with aluminum and copper conductors. Use mechanical type lugs, with cadmium-plated steel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.

2.5 EQUIPMENT RACK AND CABINET GROUND BARS

- A. Provide solid copper ground bars designed for mounting on the framework of open or cabinet-enclosed equipment racks. Ground bars shall have minimum dimensions of 6.3 mm (0.25 inch) thick x 19 mm (0.75 inch) wide, with length as required or as shown on the drawings. Provide insulators and mounting brackets.

2.6 GROUND TERMINAL BLOCKS

- A. At any equipment mounting location (e.g., backboards and hinged cover enclosures) where rack-type ground bars cannot be mounted, provide mechanical type lugs, with cadmium-plated steel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.

2.7 GROUNDING BUS BAR

- A. Pre-drilled rectangular copper bar with stand-off insulators, minimum 6.3 mm (0.25 inch) thick x 100 mm (4 inches) high in cross-section, length as shown on the drawings, with hole size, quantity, and spacing

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

per detail shown on the drawings. Provide insulators and mounting brackets.

PART 3 - EXECUTION

3.1 GENERAL

- A. Installation shall be in accordance with the NEC, as shown on the drawings, and manufacturer's instructions.
- B. System Grounding:
 - 1. Secondary service neutrals: Ground at the supply side of the secondary disconnecting means and at the related transformer.
 - 2. Separately derived systems (transformers downstream from the service entrance): Ground the secondary neutral.
- C. Equipment Grounding: Metallic piping, building structural steel, electrical enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in close proximity with electrical circuits, shall be bonded and grounded.
- D. For patient care area electrical power system grounding, conform to the latest NFPA 70 and 99.

3.2 INACCESSIBLE GROUNDING CONNECTIONS

- A. Make grounding connections, which are normally buried or otherwise inaccessible, by exothermic weld.

3.3 MEDIUM-VOLTAGE EQUIPMENT AND CIRCUITS NOT USED

- B. Duct Banks and Manholes: Provide an insulated equipment grounding conductor in each duct containing medium-voltage conductors, sized per NEC except that minimum size shall be No. 2 AWG. Bond the equipment grounding conductors to the switchgear ground bus, to all manhole grounding provisions and hardware, to the cable shield grounding provisions of medium-voltage cable splices and terminations, and to equipment enclosures.
- C. Pad-Mounted Transformers:
 - 1. Provide a driven ground rod and bond with a grounding electrode conductor to the transformer grounding pad.
 - 2. Ground the secondary neutral.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

3.4 SECONDARY VOLTAGE EQUIPMENT AND CIRCUITS

- A. Main Bonding Jumper: Bond the secondary service neutral to the ground bus in the service equipment.
- B. Metallic Piping, Building Structural Steel, and Supplemental Electrode(s):
 - 1. Provide a grounding electrode conductor sized per NEC between the service equipment ground bus and all metallic water pipe systems, building structural steel, and supplemental or made electrodes. Provide jumpers across insulating joints in the metallic piping.
 - 2. Provide a supplemental ground electrode as shown on the drawings and bond to the grounding electrode system.
- C. Switchgear, Switchboards, Unit Substations, Panelboards, Motor Control Centers, Engine-Generators, Automatic Transfer Switches, and other electrical equipment:
 - 1. Connect the equipment grounding conductors to the ground bus.
 - 2. Connect metallic conduits by grounding bushings and equipment grounding conductor to the equipment ground bus.
- D. Transformers:
 - 1. Exterior: Exterior transformers supplying interior service equipment shall have the neutral grounded at the transformer secondary. Provide a grounding electrode at the transformer.
 - 2. Separately derived systems (transformers downstream from service equipment): Ground the secondary neutral at the transformer. Provide a grounding electrode conductor from the transformer to the ground bar at the service equipment.

3.5 RACEWAY

- A. Conduit Systems:
 - 1. Ground all metallic conduit systems. All metallic conduit systems shall contain an equipment grounding conductor.
 - 2. Non-metallic conduit systems, except non-metallic feeder conduits that carry a grounded conductor from exterior transformers to interior or building-mounted service entrance equipment, shall contain an equipment grounding conductor.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

3. Metallic conduit that only contains a grounding conductor, and is provided for its mechanical protection, shall be bonded to that conductor at the entrance and exit from the conduit.
 4. Metallic conduits which terminate without mechanical connection to an electrical equipment housing by means of locknut and bushings or adapters, shall be provided with grounding bushings. Connect bushings with a equipment grounding conductor to the equipment ground bus.
- B. Feeders and Branch Circuits: Install equipment grounding conductors with all feeders, and power and lighting branch circuits.
- C. Boxes, Cabinets, Enclosures, and Panelboards:
1. Bond the equipment grounding conductor to each pullbox, junction box, outlet box, device box, cabinets, and other enclosures through which the conductor passes (except for special grounding systems for intensive care units and other critical units shown).
 2. Provide lugs in each box and enclosure for equipment grounding conductor termination.
- D. Wireway Systems:
1. Bond the metallic structures of wireway to provide electrical continuity throughout the wireway system, by connecting a No. 6 AWG bonding jumper at all intermediate metallic enclosures and across all section junctions.
 2. Install insulated No. 6 AWG bonding jumpers between the wireway system, bonded as required above, and the closest building ground at each end and approximately every 16 M (50 feet).
 3. Use insulated No. 6 AWG bonding jumpers to ground or bond metallic wireway at each end for all intermediate metallic enclosures and across all section junctions.
 4. Use insulated No. 6 AWG bonding jumpers to ground cable tray to column-mounted building ground plates (pads) at each end and approximately every 15 M (49 feet).
- E. Receptacles shall not be grounded through their mounting screws. Ground receptacles with a jumper from the receptacle green ground terminal to the device box ground screw and a jumper to the branch circuit equipment grounding conductor.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

- F. Ground lighting fixtures to the equipment grounding conductor of the wiring system. Fixtures connected with flexible conduit shall have a green ground wire included with the power wires from the fixture through the flexible conduit to the first outlet box.
- G. Fixed electrical appliances and equipment shall be provided with a ground lug for termination of the equipment grounding conductor.
- H. Raised Floors: Provide bonding for all raised floor components as shown on the drawings.
- I. Panelboard Bonding in Patient Care Areas: The equipment grounding terminal buses of the normal and essential branch circuit panel boards serving the same individual patient vicinity shall be bonded together with an insulated continuous copper conductor not less than No. 10 AWG, installed in rigid metal conduit.

3.6 OUTDOOR METALLIC FENCES AROUND ELECTRICAL EQUIPMENT NOT USED

3.7 CORROSION INHIBITORS

- A. When making grounding and bonding connections, apply a corrosion inhibitor to all contact surfaces. Use corrosion inhibitor appropriate for protecting a connection between the metals used.

3.8 CONDUCTIVE PIPING

- A. Bond all conductive piping systems, interior and exterior, to the grounding electrode system. Bonding connections shall be made as close as practical to the equipment ground bus.
- B. In operating rooms and at intensive care and coronary care type beds, bond the medical gas piping and medical vacuum piping at the outlets directly to the patient ground bus.

3.9 LIGHTNING PROTECTION SYSTEM NOT USED

3.10 MAIN ELECTRICAL ROOM GROUNDING

- A. Provide ground bus bar and mounting hardware at each main electrical room where incoming feeders are terminated, as shown on the drawings. Connect to pigtail extensions of the building grounding ring, as shown on the drawings.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

3.11 EXTERIOR LIGHT POLES NOT USED

3.12 GROUND RESISTANCE

- A. Contractor shall ground to existing building grounding system. Only install new grounds for outlying buildings that do not have a Technology Grounding System.

Grounding system resistance to ground shall not exceed 5 ohms. Make any modifications or additions to the grounding electrode system necessary for compliance without additional cost to the Government. Final tests shall ensure that this requirement is met.

3.13 GROUND ROD INSTALLATION

- A. For outdoor installations, drive each rod vertically in the earth, until top of rod is 610 mm (24 inches) below final grade.
- B. For indoor installations, leave 100 mm (4 inches) of each rod exposed.
- C. Where buried or permanently concealed ground connections are required, make the connections by the exothermic process, to form solid metal joints. Make accessible ground connections with mechanical pressure-type ground connectors.
- D. Where rock or impenetrable soil prevents the driving of vertical ground rods, install angled ground rods or grounding electrodes in horizontal trenches to achieve the specified ground resistance.

3.14 ACCEPTANCE CHECKS AND TESTS

- A. Resistance of the grounding electrode system shall be measured using a four-terminal fall-of-potential method as defined in IEEE 81. Ground resistance measurements shall be made before the electrical distribution system is energized or connected to the electric utility company ground system, and shall be made in normally dry conditions not fewer than 48 hours after the last rainfall.
- B. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.
- C. Below-grade connections shall be visually inspected by the COR prior to backfilling. The Contractor shall notify the COR 24 hours before the connections are ready for inspection.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

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Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

26 05 26 - 10
Grounding and Bonding for Electrical Systems

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

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01-01-18

SECTION 26 05 33
RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, and connection of conduit, fittings, and boxes, to form complete, coordinated, grounded raceway systems. Raceways are required for all wiring unless shown or specified otherwise.
- B. Definitions: The term conduit, as used in this specification, shall mean any or all of the raceway types specified.

1.2 RELATED WORK

- A. Section 06 10 00, ROUGH CARPENTRY: Mounting board for telephone closets.
- B. Section 07 60 00, FLASHING AND SHEET METAL: Fabrications for the deflection of water away from the building envelope at penetrations.
- C. Section 07 84 00, FIRESTOPPING: Sealing around penetrations to maintain the integrity of fire rated construction.
- D. Section 07 92 00, JOINT SEALANTS: Sealing around conduit penetrations through the building envelope to prevent moisture migration into the building.
- E. Section 09 91 00, PAINTING: Identification and painting of conduit and other devices.
- G. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- H. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- I. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Underground conduits.
- J. Section 31 20 00, EARTHWORK: Bedding of conduits.

1.3 QUALITY ASSURANCE

- A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:

- a. Size and location of main feeders.
- b. Size and location of panels and pull-boxes.
- c. Layout of required conduit penetrations through structural elements.
- d. Submit the following data for approval:
 - 1) Raceway types and sizes.
 - 2) Conduit bodies, connectors and fittings.
 - 3) Junction and pull boxes, types and sizes.

2. Certifications: Two weeks prior to final inspection, submit the following:

- a. Certification by the manufacturer that raceways, conduits, conduit bodies, connectors, fittings, junction and pull boxes, and all related equipment conform to the requirements of the drawings and specifications.
- b. Certification by the Contractor that raceways, conduits, conduit bodies, connectors, fittings, junction and pull boxes, and all related equipment have been properly installed.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American Iron and Steel Institute (AISI):

S100-12.....North American Specification for the Design of
Cold-Formed Steel Structural Members

C. National Electrical Manufacturers Association (NEMA):

C80.1-15.....Electrical Rigid Steel Conduit

C80.3-15.....Steel Electrical Metal Tubing

C80.6-05.....Electrical Intermediate Metal Conduit

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

- FB1-14.....Fittings, Cast Metal Boxes and Conduit Bodies
for Conduit, Electrical Metallic Tubing and
Cable
- FB2.10-13.....Selection and Installation Guidelines for
Fittings for use with Non-Flexible Conduit or
Tubing (Rigid Metal Conduit, Intermediate
Metallic Conduit, and Electrical Metallic
Tubing)
- FB2.20-14.....Selection and Installation Guidelines for
Fittings for use with Flexible Electrical
Conduit and Cable
- TC-2-13.....Electrical Polyvinyl Chloride (PVC) Tubing and
Conduit
- TC-3-13.....PVC Fittings for Use with Rigid PVC Conduit and
Tubing
- D. National Fire Protection Association (NFPA):
- 70-17.....National Electrical Code (NEC)
- E. Underwriters Laboratories, Inc. (UL):
- 1-05.....Flexible Metal Conduit
- 5-16.....Surface Metal Raceway and Fittings
- 6-07.....Electrical Rigid Metal Conduit - Steel
- 50-15.....Enclosures for Electrical Equipment
- 360-13.....Liquid-Tight Flexible Steel Conduit
- 467-13.....Grounding and Bonding Equipment
- 514A-13.....Metallic Outlet Boxes
- 514B-12.....Conduit, Tubing, and Cable Fittings
- 514C-14.....Nonmetallic Outlet Boxes, Flush-Device Boxes
and Covers
- 651-11.....Schedule 40 and 80 Rigid PVC Conduit and
Fittings
- 651A-11.....Type EB and A Rigid PVC Conduit and HDPE
Conduit
- 797-07.....Electrical Metallic Tubing
- 1242-14.....Electrical Intermediate Metal Conduit - Steel

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

PART 2 - PRODUCTS

2.1 MATERIAL

- A. Conduit Size: In accordance with the NEC, but not less than 13 mm (0.5-inch) unless otherwise shown. Where permitted by the NEC, 13 mm (0.5-inch) flexible conduit may be used for tap connections to recessed lighting fixtures.
- B. Conduit:
1. Size: In accordance with the NEC, but not less than 13 mm (0.5-inch).
 2. Rigid Steel Conduit (RMC): Shall conform to UL 6 and NEMA C80.1.
 4. Rigid Intermediate Steel Conduit (IMC): Shall conform to UL 1242 and NEMA C80.6.
 5. Electrical Metallic Tubing (EMT): Shall conform to UL 797 and NEMA C80.3. Maximum size not to exceed 105 mm (4 inches) and shall be permitted only with cable rated 600 V or less.
 6. Flexible Metal Conduit: Shall conform to UL 1.
 7. Liquid-tight Flexible Metal Conduit: Shall conform to UL 360.
 8. Direct Burial Plastic Conduit: Shall conform to UL 651 and UL 651A, heavy wall PVC or high density polyethylene (PE).
 9. Surface Metal Raceway: Shall conform to UL 5.
- C. Conduit Fittings:
1. Rigid Steel and Intermediate Metallic Conduit Fittings:
 - a. Fittings shall meet the requirements of UL 514B and NEMA FB1.
 - b. Standard threaded couplings, locknuts, bushings, conduit bodies, and elbows: Only steel or malleable iron materials are acceptable. Integral retractable type IMC couplings are also acceptable.
 - c. Locknuts: Bonding type with sharp edges for digging into the metal wall of an enclosure.
 - d. Bushings: Metallic insulating type, consisting of an insulating insert, molded or locked into the metallic body of the fitting. Bushings made entirely of metal or nonmetallic material are not permitted.
 - e. Erickson (Union-Type) and Set Screw Type Couplings: Approved for use in concrete are permitted for use to complete a conduit run

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

where conduit is installed in concrete. Use set screws of case-hardened steel with hex head and cup point to firmly seat in conduit wall for positive ground. Tightening of set screws with pliers is prohibited.

- f. Sealing Fittings: Threaded cast iron type. Use continuous drain-type sealing fittings to prevent passage of water vapor. In concealed work, install fittings in flush steel boxes with blank cover plates having the same finishes as that of other electrical plates in the room.
3. Electrical Metallic Tubing Fittings:
- a. Fittings and conduit bodies shall meet the requirements of UL 514B, NEMA C80.3, and NEMA FB1.
 - b. Only steel or malleable iron materials are acceptable.
 - c. Compression Couplings and Connectors: Concrete-tight and rain-tight, with connectors having insulated throats.
 - d. Indent-type connectors or couplings are prohibited.
 - e. Die-cast or pressure-cast zinc-alloy fittings or fittings made of "pot metal" are prohibited.
4. Flexible Metal Conduit Fittings:
- a. Conform to UL 514B. Only steel or malleable iron materials are acceptable.
 - b. Clamp-type, with insulated throat.
5. Liquid-tight Flexible Metal Conduit Fittings:
- a. Fittings shall meet the requirements of UL 514B and NEMA FB1.
 - b. Only steel or malleable iron materials are acceptable.
 - c. Fittings must incorporate a threaded grounding cone, a steel or plastic compression ring, and a gland for tightening. Connectors shall have insulated throats.
6. Direct Burial Plastic Conduit Fittings: Fittings shall meet the requirements of UL 514C and NEMA TC3.
7. Surface Metal Raceway Fittings: As recommended by the raceway manufacturer. Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, conduit entry fittings, accessories, and other fittings as required for complete system.
8. Expansion and Deflection Couplings:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

- a. Conform to UL 467 and UL 514B.
 - b. Accommodate a 19 mm (0.75-inch) deflection, expansion, or contraction in any direction, and allow 30 degree angular deflections.
 - c. Include internal flexible metal braid, sized to guarantee conduit ground continuity and a low-impedance path for fault currents, in accordance with UL 467 and the NEC tables for equipment grounding conductors.
 - d. Jacket: Flexible, corrosion-resistant, watertight, moisture and heat-resistant molded rubber material with stainless steel jacket clamps.
- D. Conduit Supports:
- 1. Parts and Hardware: Zinc-coat or provide equivalent corrosion protection.
 - 2. Individual Conduit Hangers: Designed for the purpose, having a pre-assembled closure bolt and nut, and provisions for receiving a hanger rod.
 - 3. Multiple Conduit (Trapeze) Hangers: Not less than 38 mm x 38 mm (1.5 x 1.5 inches), 12-gauge steel, cold-formed, lipped channels; with not less than 9 mm (0.375-inch) diameter steel hanger rods.
 - 4. Solid Masonry and Concrete Anchors: Self-drilling expansion shields, or machine bolt expansion.
- E. Outlet, Junction, and Pull Boxes:
- 1. Comply with UL-50 and UL-514A.
 - 2. Rustproof cast metal where required by the NEC or shown on drawings.
 - 3. Sheet Metal Boxes: Galvanized steel, except where shown on drawings.
- F. Metal Wireways: Equip with hinged covers, except as shown on drawings. Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for a complete system.

PART 3 - EXECUTION

3.1 PENETRATIONS

- A. Cutting or Holes:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

1. Cut holes in advance where they should be placed in the structural elements, such as ribs or beams. Obtain the approval of the COR prior to drilling through structural elements.
 2. Cut holes through concrete and masonry in new and existing structures with a diamond core drill or concrete saw. Pneumatic hammers, impact electric, hand, or manual hammer-type drills are not allowed, except when permitted by the COR where working space is limited.
- B. Firestop: Where conduits, wireways, and other electrical raceways pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING.
- C. Waterproofing: At floor, exterior wall, and roof conduit penetrations, completely seal the gap around conduit to render it watertight, as specified in Section 07 92 00, JOINT SEALANTS.

3.2 INSTALLATION, GENERAL

- A. In accordance with NEC, NEMA, UL, as shown on drawings, and as specified herein.
- B. Raceway systems used for Essential Electrical Systems (EES) shall be entirely independent of other raceway systems.
- C. Install conduit as follows:
 1. In complete mechanically and electrically continuous runs before pulling in cables or wires.
 2. Unless otherwise indicated on the drawings or specified herein, installation of all conduits shall be concealed within finished walls, floors, and ceilings.
 3. Flattened, dented, or deformed conduit is not permitted. Remove and replace the damaged conduits with new conduits.
 4. Assure conduit installation does not encroach into the ceiling height head room, walkways, or doorways.
 5. Cut conduits square, ream, remove burrs, and draw up tight.
 6. Independently support conduit at 2.4 M (8 feet) on centers with specified materials and as shown on drawings.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

7. Do not use suspended ceilings, suspended ceiling supporting members, lighting fixtures, other conduits, cable tray, boxes, piping, or ducts to support conduits and conduit runs.
 8. Support within 300 mm (12 inches) of changes of direction, and within 300 mm (12 inches) of each enclosure to which connected.
 9. Close ends of empty conduits with plugs or caps at the rough-in stage until wires are pulled in, to prevent entry of debris.
 10. Conduit installations under fume and vent hoods are prohibited.
 11. Secure conduits to cabinets, junction boxes, pull-boxes, and outlet boxes with bonding type locknuts. For rigid steel and IMC conduit installations, provide a locknut on the inside of the enclosure, made up wrench tight. Do not make conduit connections to junction box covers.
 12. Flashing of penetrations of the roof membrane is specified in Section 07 60 00, FLASHING AND SHEET METAL.
 13. Conduit bodies shall only be used for changes in direction, and shall not contain splices.
- D. Conduit Bends:
1. Make bends with standard conduit bending machines.
 2. Conduit hickey may be used for slight offsets and for straightening stubbed out conduits.
 3. Bending of conduits with a pipe tee or vise is prohibited.
- E. Layout and Homeruns:
1. Install conduit with wiring, including homeruns, as shown on drawings.
 2. Deviations: Make only where necessary to avoid interferences and only after drawings showing the proposed deviations have been submitted and approved by the COR.

3.3 CONCEALED WORK INSTALLATION

A. In Concrete:

1. Conduit: Rigid steel, IMC, or EMT. Do not install EMT in concrete slabs that are in contact with soil, gravel, or vapor barriers.
2. Align and run conduit in direct lines.
3. Install conduit through concrete beams only:
 - a. Where shown on the structural drawings.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

- b. As approved by the COR prior to construction, and after submittal of drawing showing location, size, and position of each penetration.
- 4. Installation of conduit in concrete that is less than 75 mm (3 inches) thick is prohibited.
 - a. Conduit outside diameter larger than one-third of the slab thickness is prohibited.
 - b. Space between conduits in slabs: Approximately six conduit diameters apart, and one conduit diameter at conduit crossings.
 - c. Install conduits approximately in the center of the slab so that there will be a minimum of 19 mm (0.75-inch) of concrete around the conduits.
- 5. Make couplings and connections watertight. Use thread compounds that are UL approved conductive type to ensure low resistance ground continuity through the conduits. Tightening setscrews with pliers is prohibited.
- B. Above Furred or Suspended Ceilings and in Walls:
 - 1. Conduit for Conductors Above 600 V: Rigid steel. Mixing different types of conduits in the same system is prohibited.
 - 2. Conduit for Conductors 600 V and Below: Rigid steel, IMC, or EMT. Mixing different types of conduits in the same system is prohibited.
 - 3. Align and run conduit parallel or perpendicular to the building lines.
 - 4. Connect recessed lighting fixtures to conduit runs with maximum 1.8 M (6 feet) of flexible metal conduit extending from a junction box to the fixture.
 - 5. Tightening set screws with pliers is prohibited.
 - 6. For conduits running through metal studs, limit field cut holes to no more than 70% of web depth. Spacing between holes shall be at least 457 mm (18 inches). Cuts or notches in flanges or return lips shall not be permitted.

3.4 EXPOSED WORK INSTALLATION

- A. Unless otherwise indicated on drawings, exposed conduit is only permitted in mechanical and electrical rooms.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

- B. Conduit for Conductors Above 600 V: Rigid steel. Mixing different types of conduits in the system is prohibited.
- C. Conduit for Conductors 600 V and Below: Rigid steel, IMC, or EMT. Mixing different types of conduits in the system is prohibited.
- D. Align and run conduit parallel or perpendicular to the building lines.
- E. Install horizontal runs close to the ceiling or beams and secure with conduit straps.
- F. Support horizontal or vertical runs at not over 2.4 M (8 feet) intervals.
- G. Surface Metal Raceways: Use only where shown on drawings.
- H. Painting:
 - 1. Paint exposed conduit as specified in Section 09 91 00, PAINTING.
 - 2. Paint all conduits containing cables rated over 600 V safety orange. Refer to Section 09 91 00, PAINTING for preparation, paint type, and exact color. In addition, paint legends, using 50 mm (2 inch) high black numerals and letters, showing the cable voltage rating. Provide legends where conduits pass through walls and floors and at maximum 6 M (20 feet) intervals in between.

3.5 DIRECT BURIAL INSTALLATION

Refer to Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION.

3.6 HAZARDOUS LOCATIONS

- A. Use rigid steel conduit only.
- B. Install UL approved sealing fittings that prevent passage of explosive vapors in hazardous areas equipped with explosion-proof lighting fixtures, switches, and receptacles, as required by the NEC.

3.7 WET OR DAMP LOCATIONS

- A. Use rigid steel or IMC conduits unless as shown on drawings.
- B. Provide sealing fittings to prevent passage of water vapor where conduits pass from warm to cold locations, i.e., refrigerated spaces, constant-temperature rooms, air-conditioned spaces, building exterior walls, roofs, or similar spaces.
- C. Use rigid steel or IMC conduit within 1.5 M (5 feet) of the exterior and below concrete building slabs in contact with soil, gravel, or vapor barriers, unless as shown on drawings. Conduit shall be half-

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

lapped with 10 mil PVC tape before installation. After installation, completely recoat or retape any damaged areas of coating.

- D. Conduits run on roof shall be supported with integral galvanized lipped steel channel, attached to UV-inhibited polycarbonate or polypropylene blocks every 2.4 M (8 feet) with 9 mm (3/8-inch) galvanized threaded rods, square washer and locknut. Conduits shall be attached to steel channel with conduit clamps.

3.8 MOTORS AND VIBRATING EQUIPMENT

- A. Use flexible metal conduit for connections to motors and other electrical equipment subject to movement, vibration, misalignment, cramped quarters, or noise transmission.
- B. Use liquid-tight flexible metal conduit for installation in exterior locations, moisture or humidity laden atmosphere, corrosive atmosphere, water or spray wash-down operations, inside airstream of HVAC units, and locations subject to seepage or dripping of oil, grease, or water.
- C. Provide a green equipment grounding conductor with flexible and liquid-tight flexible metal conduit.

3.9 EXPANSION JOINTS

- A. Conduits 75 mm (3 inch) and larger that are secured to the building structure on opposite sides of a building expansion joint require expansion and deflection couplings. Install the couplings in accordance with the manufacturer's recommendations.
- B. Provide conduits smaller than 75 mm (3 inch) with junction boxes on both sides of the expansion joint. Connect flexible metal conduits to junction boxes with sufficient slack to produce a 125 mm (5 inch) vertical drop midway between the ends of the flexible metal conduit. Flexible metal conduit shall have a green insulated copper bonding jumper installed. In lieu of this flexible metal conduit, expansion and deflection couplings as specified above are acceptable.
- C. Install expansion and deflection couplings where shown.

3.10 CONDUIT SUPPORTS

- A. Safe working load shall not exceed one-quarter of proof test load of fastening devices.
- B. Use pipe straps or individual conduit hangers for supporting individual conduits.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

- C. Support multiple conduit runs with trapeze hangers. Use trapeze hangers that are designed to support a load equal to or greater than the sum of the weights of the conduits, wires, hanger itself, and an additional 90 kg (200 lbs). Attach each conduit with U-bolts or other approved fasteners.
- D. Support conduit independently of junction boxes, pull-boxes, fixtures, suspended ceiling T-bars, angle supports, and similar items.
- E. Fasteners and Supports in Solid Masonry and Concrete:
 - 1. New Construction: Use steel or malleable iron concrete inserts set in place prior to placing the concrete.
 - 2. Existing Construction:
 - a. Steel expansion anchors not less than 6 mm (0.25-inch) bolt size and not less than 28 mm (1.125 inch) in embedment.
 - b. Power set fasteners not less than 6 mm (0.25-inch) diameter with depth of penetration not less than 75 mm (3 inch).
 - c. Use vibration and shock-resistant anchors and fasteners for attaching to concrete ceilings.
- F. Hollow Masonry: Toggle bolts.
- G. Bolts supported only by plaster or gypsum wallboard are not acceptable.
- H. Metal Structures: Use machine screw fasteners or other devices specifically designed and approved for the application.
- I. Attachment by wood plugs, rawl plug, plastic, lead or soft metal anchors, or wood blocking and bolts supported only by plaster is prohibited.
- J. Chain, wire, or perforated strap shall not be used to support or fasten conduit.
- K. Spring steel type supports or fasteners are prohibited for all uses except horizontal and vertical supports/fasteners within walls.
- L. Vertical Supports: Vertical conduit runs shall have riser clamps and supports in accordance with the NEC and as shown. Provide supports for cable and wire with fittings that include internal wedges and retaining collars.

3.11 BOX INSTALLATION

- A. Boxes for Concealed Conduits:
 - 1. Flush-mounted.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

2. Provide raised covers for boxes to suit the wall or ceiling, construction, and finish.
- B. In addition to boxes shown, install additional boxes where needed to prevent damage to cables and wires during pulling-in operations or where more than the equivalent of 4-90 degree bends are necessary.
- C. Locate pullboxes so that covers are accessible and easily removed. Coordinate locations with piping and ductwork where installed above ceilings.
- D. Remove only knockouts as required. Plug unused openings. Use threaded plugs for cast metal boxes and snap-in metal covers for sheet metal boxes.
- E. Outlet boxes mounted back-to-back in the same wall are prohibited. A minimum 600 mm (24 inch) center-to-center lateral spacing shall be maintained between boxes.
- F. Flush-mounted wall or ceiling boxes shall be installed with raised covers so that the front face of raised cover is flush with the wall. Surface-mounted wall or ceiling boxes shall be installed with surface-style flat or raised covers.
- G. Minimum size of outlet boxes for ground fault circuit interrupter (GFCI) receptacles is 100 mm (4 inches) square x 55 mm (2.125 inches) deep, with device covers for the wall material and thickness involved.
- H. Stencil or install phenolic nameplates on covers of the boxes identified on riser diagrams; for example "SIG-FA JB No. 1."
- I. On all branch circuit junction box covers, identify the circuits with black marker.

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Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

SECTION 26 05 41
UNDERGROUND ELECTRICAL CONSTRUCTION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, and connection of underground ducts and raceways, and precast manholes and pullboxes to form a complete underground electrical raceway system.
- B. The terms "duct" and "conduit" are used interchangeably in this section.

1.2 RELATED WORK

- A. Section 07 92 00, JOINT SEALANTS: Sealing of conduit penetrations.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- D. Section 31 20 00, EARTH MOVING Section 31 20 11, EARTH MOVING (SHORT FORM): Trenching, backfill, and compaction.

1.3 QUALITY ASSURANCE

- A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Coordinate layout and installation of ducts, manholes, and pullboxes with final arrangement of other utilities, site grading, and surface features.

1.4 SUBMITTALS

- A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Submit information on manholes, pullboxes, ducts, and hardware. Submit manhole plan and elevation drawings, showing openings,

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

pulling irons, cable supports, cover, ladder, sump, and other accessories.

- c. Proposed deviations from the drawings shall be clearly marked on the submittals. If it is necessary to locate manholes, pullboxes, or duct banks at locations other than shown on the drawings, show the proposed locations accurately on scaled site drawings, and submit to the COR for approval prior to construction.

2. Certifications: Two weeks prior to the final inspection, submit the following.

- a. Certification by the manufacturer that the materials conform to the requirements of the drawings and specifications.
- b. Certification by the Contractor that the materials have been properly installed, connected, and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American Concrete Institute (ACI):

Building Code Requirements for Structural Concrete
318-14/318M-14.....Building Code Requirements for Structural
Concrete & Commentary
SP-66-04.....ACI Detailing Manual

C. American National Standards Institute (ANSI):

77-14.....Underground Enclosure Integrity

D. American Society for Testing and Materials (ASTM):

C478 REV A-15.....Standard Specification for Precast Reinforced
Concrete Manhole Sections
C858-10.....Underground Precast Concrete Utility Structures
C990-09.....Joints for Concrete Pipe, Manholes and Precast
Box Sections Using Preformed Flexible Joint
Sealants.

E. National Electrical Manufacturers Association (NEMA):

TC 2-13.....Electrical Polyvinyl Chloride (PVC) Conduit

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

- TC 3-15.....Polyvinyl Chloride (PVC) Fittings for Use With
Rigid PVC Conduit And Tubing
- TC 6 & 8-13.....Polyvinyl Chloride (PVC) Plastic Utilities Duct
For Underground Installations
- TC 9-04.....Fittings For Polyvinyl Chloride (PVC) Plastic
Utilities Duct For Underground Installation
- F. National Fire Protection Association (NFPA):
- 70-17.....National Electrical Code (NEC)
- 70E-15.....National Electrical Safety Code
- G. Underwriters Laboratories, Inc. (UL):
- 6-07.....Electrical Rigid Metal Conduit-Steel
- 467-13.....Grounding and Bonding Equipment
- 651-11.....Schedule 40, 80, Type EB and A Rigid PVC
Conduit and Fittings
- 651A-11.....Schedule 40 and 80 High Density Polyethylene
(HDPE) Conduit

PART 2 - PRODUCTS

2.1 PRE-CAST CONCRETE MANHOLES AND HARDWARE

- A. Structure: Factory-fabricated, reinforced-concrete, monolithically-poured walls and bottom. Frame and cover shall form top of manhole.
- B. Cable Supports:
1. Cable stanchions shall be hot-rolled, heavy duty, hot-dipped galvanized "T" section steel, 56 mm (2.25 inches) x 6 mm (0.25 inch) in size, and punched with 14 holes on 38 mm (1.5 inches) centers for attaching cable arms.
 2. Cable arms shall be 5 mm (0.1875 inch) gauge, hot-rolled, hot-dipped galvanized sheet steel, pressed to channel shape. Arms shall be approximately 63 mm (2.5 inches) wide x 350 mm (14 inches) long.
 3. Insulators for cable supports shall be porcelain, and shall be saddle type or type that completely encircles the cable.
 4. Equip each cable stanchion with one spare cable arm, with three spare insulators for future use.
- C. Ladder: Aluminum with 400 mm (16 inches) rung spacing. Provide securely-mounted ladder for every manhole over 1.2 M (4 feet) deep.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

D. Ground Rod Sleeve: Provide a 75 mm (3 inches) PVC sleeve in manhole floors so that a driven ground rod may be installed.

E. Sump: Provide 305 mm x 305 mm (12 inches x 12 inches) covered sump frame and grated cover.

2.2 PULLBOXES

A. General: Size as indicated on the drawings. Provide pullboxes with weatherproof, non-skid covers with recessed hook eyes, secured with corrosion- and tamper-resistant hardware. Cover material shall be identical to pullbox material. Covers shall have molded lettering, ELECTRIC or SIGNAL as applicable. Pullboxes shall comply with the requirements of ANSI 77 Tier 15 loading. Provide pulling irons, 22 mm (0.875 inch) diameter galvanized steel bar with exposed triangular-shaped opening.

B. Polymer Concrete Pullboxes: Shall be molded of sand, aggregate, and polymer resin, and reinforced with steel, fiberglass, or both. Pullbox shall have open bottom.

D. Concrete Pullboxes: Shall be monolithically-poured reinforced concrete.

2.3 DUCTS

A. Number and sizes shall be as shown on the drawings.

B. Ducts (concrete-encased):

1. Plastic Duct:

a. UL 651 and 651A Schedule 40 PVC conduit.

b. Duct shall be suitable for use with 90° C (194° F) rated conductors.

2. Conduit Spacers: Prefabricated plastic.

2.4 GROUNDING

A. Ground Rods and Ground Wire: Per Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

2.5 WARNING TAPE

A. 4-mil polyethylene 75 mm (3 inches) wide detectable tape, red with black letters, imprinted with "CAUTION - BURIED ELECTRIC CABLE BELOW" or similar.

2.6 PULL ROPE FOR SPARE DUCTS

A. Plastic with 890 N (200 lb) minimum tensile strength.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

PART 3 - EXECUTION

3.1 MANHOLE AND PULLBOX INSTALLATION

- A. Assembly and installation shall be per the requirements of the manufacturer.
 - 1. Install manholes and pullboxes level and plumb.
 - 2. Units shall be installed on a 300 mm (12 inches) thick level bed of 90% compacted granular fill, well-graded from the 25 mm (1 inch) sieve to the No. 4 sieve. Granular fill shall be compacted with a minimum of four passes with a plate compactor.
- B. Access: Ensure the top of frames and covers are flush with finished grade.
- C. Grounding in Manholes:
 - 1. Ground Rods in Manholes: Drive a ground rod into the earth, through the floor sleeve, after the manhole is set in place. Fill the sleeve with sealant to make a watertight seal. Rods shall protrude approximately 100 mm (4 inches) above the manhole floor.
 - 2. Install a No. 3/0 AWG bare copper ring grounding conductor around the inside perimeter of the manhole and anchor to the walls with metallic cable clips.
 - 3. Connect the ring grounding conductor to the ground rod by an exothermic welding process.
 - 4. Bond the ring grounding conductor to the duct bank equipment grounding conductors, the exposed non-current carrying metal parts of racks, sump covers, and like items in the manholes with a minimum No. 6 AWG bare copper jumper using an exothermic welding process.

3.2 TRENCHING

- A. Refer to Section 31 20 11 EARTH MOVING (SHORT FORM) for trenching, backfilling, and compaction.
- B. Before performing trenching work at existing facilities, a Ground Penetrating Radar Survey shall be carefully performed by a certified technician to reveal all existing underground ducts, conduits, cables, and other utility systems.
- C. Work with extreme care near existing ducts, conduits, and other utilities to avoid damaging them.
- D. Cut the trenches neatly and uniformly.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

E. For Concrete-Encased Ducts:

1. After excavation of the trench, stakes shall be driven in the bottom of the trench at 1.2 M (4 feet) intervals to establish the grade and route of the duct bank.
2. Pitch the trenches uniformly toward manholes or both ways from high points between manholes for the required duct line drainage. Avoid pitching the ducts toward buildings wherever possible.
3. The walls of the trench may be used to form the side walls of the duct bank, provided that the soil is self-supporting and that the concrete envelope can be poured without soil inclusions. Forms are required where the soil is not self-supporting.
4. After the concrete-encased duct has sufficiently cured, the trench shall be backfilled to grade with earth, and appropriate warning tape installed.

F. Individual conduits to be installed under existing paved areas and roads that cannot be disturbed shall be jacked into place using rigid metal conduit, or bored using plastic utilities duct or PVC conduit, as approved by the COR.

3.3 DUCT INSTALLATION

A. General Requirements:

1. Ducts shall be in accordance with the NEC, as shown on the drawings, and as specified.
2. Join and terminate ducts with fittings recommended by the manufacturer.
3. Slope ducts to drain towards manholes and pullboxes, and away from building and equipment entrances. Pitch not less than 100 mm (4 inches) in 30 M (100 feet).
4. Underground conduit stub-ups and sweeps to equipment inside of buildings shall be galvanized rigid metal conduit half-lap wrapped with PVC tape and shall extend a minimum of 1.5 M (5 feet) outside the building foundation. Tops of conduits below building slab shall be minimum 610 mm (24 inches) below bottom of slab.
5. Stub-ups and sweeps to equipment mounted on outdoor concrete slabs shall be galvanized rigid metal conduit half-lap wrapped with PVC

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

- tape, and shall extend a minimum of 1.5 M (5 feet) away from the edge of slab.
6. Install insulated grounding bushings on the conduit terminations.
 7. Radius for sweeps shall be sufficient to accomplish pulls without damage. Minimum radius shall be six times conduit diameter.
 8. All multiple conduit runs shall have conduit spacers. Spacers shall securely support and maintain uniform spacing of the duct assembly a minimum of 75 mm (3 inches) above the bottom of the trench during the concrete pour. Spacer spacing shall not exceed 1.5 M (5 feet). Secure spacers to ducts and earth to prevent floating during concrete pour. Provide nonferrous tie wires to prevent displacement of the ducts during concrete pour. Tie wires shall not act as substitute for spacers.
 9. Duct lines shall be installed no less than 300 mm (12 inches) from other utility systems, such as water, sewer, chilled water.
 10. Clearances between individual ducts:
 - a. For similar services, not less than 75 mm (3 inches).
 - b. For power and signal services, not less than 150 mm (6 inches).
 11. Duct lines shall terminate at window openings in manhole walls as shown on the drawings. All ducts shall be fitted with end bells.
 12. Couple the ducts with proper couplings. Stagger couplings in rows and layers to ensure maximum strength and rigidity of the duct bank.
 13. Keep ducts clean of earth, sand, or gravel, and seal with tapered plugs upon completion of each portion of the work.
 14. Spare Ducts: Where spare ducts are shown, they shall have a nylon pull rope installed. They shall be capped at each end and labeled as to location of the other end.
 15. Duct Identification: Place continuous strip of warning tape approximately 300 mm (12 inches) above ducts before backfilling trenches. Warning tape shall be preprinted with proper identification.
 16. Duct Sealing: Seal ducts, including spare ducts, at building entrances and at outdoor terminations for equipment, with a suitable non-hardening compound to prevent the entrance of foreign objects and material, moisture, and gases.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

17. Use plastic ties to secure cables to insulators on cable arms. Use minimum two ties per cable per insulator.

B. Concrete-Encased Ducts:

1. Install concrete-encased ducts for medium-voltage systems, low-voltage systems, and signal systems, unless otherwise shown on the drawings.
2. Duct banks shall be single or multiple duct assemblies encased in concrete. Ducts shall be uniform in size and material throughout the installation.
3. Tops of concrete-encased ducts shall be:
 - a. Not less than 600 mm (24 inches) and not less than shown on the drawings, below finished grade.
 - b. Not less than 750 mm (30 inches) and not less than shown on the drawings, below roads and other paved surfaces.
 - c. Additional burial depth shall be required in order to accomplish NEC-required minimum bend radius of ducts.
 - d. Conduits crossing under grade slab construction joints shall be installed a minimum of 1.2 M (4 feet) below slab.
4. Extend the concrete envelope encasing the ducts not less than 75 mm (3 inches) beyond the outside walls of the outer ducts.
5. Within 3 M (10 feet) of building and manhole wall penetrations, install reinforcing steel bars at the top and bottom of each concrete envelope to provide protection against vertical shearing.
6. Install reinforcing steel bars at the top and bottom of each concrete envelope of all ducts underneath roadways and parking areas.
7. Where new ducts and concrete envelopes are to be joined to existing manholes, pullboxes, ducts, and concrete envelopes, make the joints with the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions.
8. Duct joints in concrete may be placed side by side horizontally, but shall be staggered at least 150 mm (6 inches) vertically.
9. Pour each run of concrete envelope between manholes or other terminations in one continuous pour. If more than one pour is necessary, terminate each pour in a vertical plane and install 19 mm

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

(0.75 inch) reinforcing rod dowels extending 450 mm (18 inches) into concrete on both sides of joint near corners of envelope.

10. Pour concrete so that open spaces are uniformly filled. Do not agitate with power equipment unless approved by COR.

C. Direct-Burial Ducts: NOT USED

D. Connections to Manholes: Ducts connecting to manholes shall be flared to have an enlarged cross-section to provide additional shear strength. Dimensions of the flared cross-section shall be larger than the corresponding manhole opening dimensions by no less than 300 mm (12 inches) in each direction. Perimeter of the duct bank opening in the manhole shall be flared toward the inside or keyed to provide a positive interlock between the duct and the wall of the manhole. Use vibrators when this portion of the encasement is poured to ensure a seal between the envelope and the wall of the structure.

E. Connections to Existing Manholes: For duct connections to existing manholes, break the structure wall out to the dimensions required and preserve the steel in the structure wall. Cut steel and extend into the duct bank envelope. Chip the perimeter surface of the duct bank opening to form a key or flared surface, providing a positive connection with the duct bank envelope.

F. Connections to Existing Ducts: Where connections to existing ducts are indicated, excavate around the ducts as necessary. Cut off the ducts and remove loose concrete from inside before installing new ducts. Provide a reinforced-concrete collar, poured monolithically with the new ducts, to take the shear at the joint of the duct banks.

G. Partially-Completed Ducts: During construction, wherever a construction joint is necessary in a duct bank, prevent debris such as mud and dirt from entering ducts by providing suitable plugs. Fit concrete envelope of a partially completed ducts with reinforcing steel extending a minimum of 600 mm (2 feet) back into the envelope and a minimum of 600 mm (2 feet) beyond the end of the envelope. Provide one No. 4 bar in each corner, 75 mm (3 inches) from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately 300 mm (12 inches) apart. Restrain reinforcing assembly from moving during pouring of concrete.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

3.4 ACCEPTANCE CHECKS AND TESTS

A. Duct Testing and Cleaning:

1. Upon completion of the duct installation, a standard flexible mandrel shall be pulled through each duct to loosen particles of earth, sand, or foreign material left in the duct, and to test for out-of-round conditions.
2. The mandrel shall be not less than 300 mm (12 inches) long, and shall have a diameter not less than 13 mm (0.5 inch) less than the inside diameter of the duct. A brush with stiff bristles shall then be pulled through each duct to remove the loosened particles. The diameter of the brush shall be the same as, or slightly larger than, the diameter of the duct.
3. If testing reveals obstructions or out-of-round conditions, the Contractor shall replace affected section(s) of duct and retest to the satisfaction of the COR.
4. Mandrel pulls shall be witnessed by the COR.

---END---

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

SECTION 26 09 23
LIGHTING CONTROLS

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the furnishing, installation and connection of the lighting controls. When placing occupancy sensors in the data center, consider blocking from computer cabinets, which may require additional occupancy sensors. Install occupancy sensors in data center to control 25% of the space at one time.

1.2 RELATED WORK

- A. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Interface of lighting controls with HVAC control systems.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General requirements that are common to more than one section of Division 26.
- C. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Cables and wiring.
- D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.
- E. Section 26 24 16, PANELBOARDS: Panelboard enclosure and interior bussing used for lighting control panels.
- F. Section 26 27 26, WIRING DEVICES: Wiring devices used for control of the lighting systems.
- G. Section 26 51 00, INTERIOR LIGHTING: Luminaire ballast and drivers used in control of lighting systems.

1.3 QUALITY ASSURANCE

- A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:
 - 1. Shop Drawings:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

- a. Submit the following information for each type of lighting controls.
 - b. Material and construction details.
 - c. Physical dimensions and description.
 - d. Wiring schematic and connection diagram.
 - e. Installation details.
2. Manuals:
 - a. Submit, simultaneously with the shop drawings, complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
 - b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
 - a. Certification by the Contractor that the lighting control systems have been properly installed and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. National Electrical Manufacturer's Association (NEMA):
- C. National Fire Protection Association (NFPA):
 - 70-17.....National Electrical Code (NEC)
- D. Underwriters Laboratories, Inc. (UL):
 - 20-10.....Standard for General-Use Snap Switches
 - 98-16.....Enclosed and Dead-Front Switches
 - 916-15.....Standard for Energy Management Equipment Systems
 - 924-16.....Emergency Lighting and Power Equipment (for use when controlling emergency circuits).

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

PART 2 - PRODUCTS

NOTE: Nlight design (on / off) switches will be used in the new TR Rooms. LED lights run off of 10V DC, along with switch on wall. Lights are normally off in TR Rooms except when work is being performed. Occupancy sensors shall not be used.

2.1 ELECTRONIC TIME SWITCHES NOT USED

2.2 ELECTROMECHANICAL-DIAL TIME SWITCHES NOT USED

2.3 OUTDOOR PHOTOELECTRIC SWITCHES NOT USED

2.4 TIMER SWITCHES NOT USED

2.5 CEILING-MOUNTED PHOTOELECTRIC SWITCHES

A. SOLID-STATE, LIGHT-LEVEL SENSOR UNIT, WITH SEPARATE RELAY UNIT.

1. Sensor Output: Contacts rated to operate the associated relay.
Sensor shall be powered from the relay unit.
2. Relay Unit: Dry contacts rated for 20A ballast load at 120 volt and 277 volt, for 13A tungsten at 120 volt, and for 1 hp at 120 volt.
3. Monitoring Range: 108 to 2152 lx (10 to 200 fc with an adjustment for turn-on and turn-off levels.
4. Time Delay: Adjustable from 5 to 300 seconds, with deadband adjustment.

2.6 SKYLIGHT PHOTOELECTRIC SENSORS NOT USED

2.7 INDOOR OCCUPANCY SENSORS

Ceiling-mounting, solid-state units with a power supply and relay unit, suitable for the environmental conditions in which installed.

1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a 1 to 15 minute adjustable time delay for turning lights off.
2. Sensor Output: Contacts rated to operate the connected relay.
Sensor shall be powered from the relay unit.
3. Relay Unit: Dry contacts rated for 20A ballast load at 120 volt and 277 volt, for 13A tungsten at 120 volt, and for 1 hp at 120 volt.
4. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
6. Bypass Switch: Override the on function in case of sensor failure.
7. Manual/automatic selector switch.
8. Automatic Light-Level Sensor: Adjustable from 21.5 to 2152 lx (2 to 200 fc); keep lighting off when selected lighting level is present.
9. Faceplate for Wall-Switch Replacement Type: Refer to wall plate material and color requirements for toggle switches, as specified in Section 26 27 26, WIRING DEVICES.

C. Detection Coverage: Shall be sufficient to provide coverage as required by sensor locations shown on drawing.

2.8 INDOOR VACANCY SENSOR SWITCH NOT USED

2.9 OUTDOOR MOTION SENSOR (PIR) NOT USED

2.10 LIGHTING CONTROL SYSTEM - RELAY PANEL TYPE (NETWORK) NOT USED

2.12 LIGHTING CONTROL SYSTEM - DISTRIBUTIVE RELAY TYPE NOT USED

2.13 LIGHTING CONTROL SYSTEM - CIRCUIT BREAKER PANEL TYPE NOT USED

2.14 LIGHTING CONTROL SYSTEM - DIGITAL ADDRESSABLE LIGHTING INTERFACE (DALI) NOT USED

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the NEC, manufacturer's instructions, as shown on the drawings, and as specified. Fixtures will be powered with 120VAC, and code compliant wiring will be utilized for controls from the switch to the fixtures.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations.
- B. Upon completion of installation, conduct an operating test to show that equipment operates in accordance with requirements of this section.

3.3 FOLLOW-UP VERIFICATION

Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that the lighting control devices are in good operating condition and properly performing the intended function in the presence of COR.

3.4 INSTRUCTION NOT REQUIRED

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

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Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

26 09 23 - 5
Lighting Controls

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

SECTION 26 12 19
PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of the pad-mounted, liquid-filled, medium-voltage transformers, indicated as transformers in this section.

1.2 RELATED WORK

- A. Section 03 30 00, CAST-IN-PLACE CONCRETE: Requirements for concrete equipment pads.
- B. Section 09 06 00, SCHEDULE FOR FINISHES: Finishes for electrical equipment.
- D. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- E. Section 26 05 13, MEDIUM-VOLTAGE CABLES: Medium-voltage cables.
- F. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground currents.
- G. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Manholes, pull-boxes, and ducts for underground raceway systems.
- H. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: Short circuit and coordination study, and requirements for a coordinated electrical system.

1.3 QUALITY ASSURANCE

- A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

- A. Factory Tests shall be required.
- B. Factory Tests shall be in accordance with Paragraph, MANUFACTURED PRODUCTS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirement:
1. Transformers shall be thoroughly tested at the factory to ensure that there are no electrical or mechanical defects. Tests shall be

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

conducted as per IEEE Standards. Factory tests shall be certified.

The following tests shall be performed:

- a. Perform insulation-resistance tests, winding-to-winding and each winding-to-ground.
- b. Perform turns-ratio tests at all tap positions.

1.5 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:

- a. Submit sufficient information to demonstrate compliance with drawings and specifications.
- b. Include electrical ratings, nameplate data, impedance, outline drawing with dimensions and front, top, and side views, weight, mounting details, decibel rating, termination information, temperature rise, no-load and full-load losses, regulation, overcurrent protection, connection diagrams, and accessories.
- c. Complete nameplate data, including manufacturer's name and catalog number.

2. Manuals:

- a. When submitting the shop drawings, submit companion copies of complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
 - 1) Identify terminals on wiring diagrams to facilitate installation, maintenance, and operation.
 - 2) Indicate on wiring diagrams the internal wiring for each piece of equipment and interconnections between the pieces of equipment.
 - 3) Approvals will be based on complete submissions of manuals, together with shop drawings.
- b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

- 1) Update the manual to include any information necessitated by shop drawing approval.
- 2) Show all terminal identification.
- 3) Include information for testing, repair, troubleshooting, assembly, disassembly, and recommended maintenance intervals.
- 4) Provide a replacement parts list with current prices. Include a list of recommended spare parts, tools, and instruments for testing and maintenance purposes.

B. Certifications:

1. Two weeks prior to the final inspection, submit the following certifications.
 - a. Certification by the manufacturer that the transformers conform to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that the transformers have been properly installed, connected, and tested.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. American Society for Testing and Materials (ASTM):
- D3487-16.....Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus
- C. Institute of Electrical and Electronic Engineers (IEEE):
- 48-20.....Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5kV Through 765kV or Extruded Insulation Rated 2.5kV Through 500kV
- 386-16.....Separable Insulated Connector Systems for Power Distribution Systems Above 600 V
- 592-18.....Insulation Shields on Medium-Voltage (15 kV - 35 kV) Cable Joints and Separable Connectors
- C2-17.....National Electrical Safety Code

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

- C37.42-16.....Specifications for High-Voltage (>1000 V) Fuses
and Accessories
- C57.12.00-21.....Liquid-Immersed Distribution, Power and
Regulating Transformers
- C57.12.10-17.....Liquid-Immersed Power Transformers
- C57.12.25-90.....Pad-Mounted, Compartmental-Type, Self-Cooled,
Single-Phase Distribution-Transformers with
Separable Insulated High Voltage Connectors;
High Voltage, 34500 Grd Y/19920 Volts and
Below; Low-Voltage 240/120 Volts; 167 kVA and
Smaller Requirements
- C57.12.28-14.....Pad-Mounted Equipment - Enclosure Integrity
- C57.12.29-14.....Pad-Mounted Equipment- Enclosure Integrity for
Coastal Environments
- C57.12.34-15.....Pad-Mounted, Compartmental-Type, Self-Cooled,
Three-Phase Distribution Transformers, 5 MVA
and Smaller; High Voltage, 34.5 kV Nominal
System Voltage and Below; Low Voltage, 15kV
Nominal System Voltage and Below
- C57.12.90-21.....Test Code for Liquid-Immersed Distribution,
Power, and Regulating Transformers
- C62.11-20.....Metal-Oxide Surge Arresters for AC Power
Circuits
- D. International Code Council (ICC):
IBC-21.....International Building Code
- E. National Electrical Manufacturers Association (NEMA):
TR 1-13(R2019).....Transformers, Regulators, and Reactors
- F. National Fire Protection Association (NFPA):
70-23.....National Electrical Code (NEC)
- G. Underwriters Laboratories Inc. (UL):
467-13.....Grounding and Bonding Equipment
- H. United States Department of Energy (DOE):
10 CFR Part 431.....Energy Efficiency Program for Certain
Commercial and Industrial Equipment

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Transformers shall be in accordance with ASTM, IEEE, NFPA, UL, as shown on the drawings, and as specified herein. Each transformer shall be assembled as an integral unit by a single manufacturer.
- B. Transformers shall be complete, outdoor type, continuous duty, integral assembly, grounded, tamper-resistant, and with liquid-immersed windings.
- C. Ratings shall not be less than shown on the drawings.
- D. Completely fabricate transformers at the factory so that only the external cable connections are required at the project site.
- E. Thoroughly clean, phosphatize, and finish all the metal surfaces at the factory with a rust-resistant primer and dark green enamel finish coat, except where a different color is specified in Section 09 06 00, SCHEDULE FOR FINISHES. All surfaces of the transformer that will be in contact with the concrete pad shall be treated with corrosion-resistant compounds and epoxy resin or a rubberized sealing compound.

2.2 COMPARTMENTS

- A. Construction:
 - 1. Enclosures shall be weatherproof and in accordance with IEEE C57.12.28
 - 2. The medium- and low-voltage compartments shall be separated with a steel barrier that extends the full height and depth of the compartments.
 - 3. The compartments shall be constructed of sheet steel (gauge to meet ANSI requirements) with bracing and with reinforcing gussets using jig welds to assure rectangular rigidity.
 - 4. All bolts, nuts, and washers shall be cadmium-plated steel.
 - 5. Sufficient space shall be provided for equipment, cabling, and terminations within the compartments.
 - 6. Affix transformer nameplate permanently within the low-voltage compartment. Voltage and kVA rating, connection configuration, impedance, date of manufacture, and serial number shall be shown on the nameplate.
- B. Doors:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

1. Provide a separate door for each compartment with provisions for a single padlock to secure all doors. Provide each compartment door with open-position doorstops and corrosion-resistant tamperproof hinges welded in place. The medium-voltage compartment door shall be mechanically prevented from opening unless the low-voltage compartment door is open.
2. The secondary compartment door shall have a one-piece steel handle and incorporate three-point locking mechanisms.
3. Provide a 50 mm (2 inches) size padlock for each assembly, as approved by the COR. Padlocks shall be keyed to the COR's established key set. Firmly attach the padlock to the door assembly by a chain.

2.3 BIL RATING

- A. 15 kV class equipment shall have a minimum 95 kV BIL rating.

2.4 TRANSFORMER FUSE ASSEMBLY

- A. The primary fuse assembly shall be load-break combination fuse and dry-well fuse holder rated for system voltage, rated for 10 load makes and 10 load breaks, with rated 200 amp load current at 75% power factor, 10,000 symmetrical A close-in on fault duty, and 95 kV BIL. The entire fuse assembly shall be removable through the use of hot stick.
 1. The fuses shall be concealed, hot stick removable, 50,000 A symmetrical interrupting, non-expulsion, current-limiting primary distribution type, of the size and voltage class as shown on the drawings. The fuses shall operate within the fuse holder as a unit disconnecting means. Fuses shall be in accordance with ANSI C37.47.
 2. Transformers shall not have internal "weak link" fuses that require transformer tank cover removal for replacement.
 3. For units above 500 kVA using fusing above the 50 A 15 kV and 100 A 5 kV application, a clip-mounted arrangement of the current limiting fuses (i.e., live-front configuration) is required.

2.5 PRIMARY CONNECTIONS

- A. Primary connections shall be 200 A dead-front loadbreak wells and inserts for cable sizes shown on the drawings.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

2.6 MEDIUM-VOLTAGE SWITCH

- A. The transformer primary disconnect switch shall be a manual 15kv switch, internal, gang-operated, load-interrupter type, rated at ampacity and system voltage as shown on the drawings, with a minimum momentary withstand rating of not less than the calculated available fault current shown on the drawings.

2.7 MEDIUM-VOLTAGE TERMINATIONS

- A. Terminate the medium-voltage cables in the primary compartment with 200 A loadbreak premolded rubber elbow connectors, suitable for submersible applications. Elbow connectors shall have a semi-conductive shield material covering the housing. The separable connector system shall include the loadbreak elbow, the bushing insert, and the bushing well. Separable connectors shall comply with the requirements of IEEE 386, and shall be interchangeable between suppliers. Allow sufficient slack in medium-voltage cable, ground, and drain wires to permit elbow connectors to be moved to their respective parking stands.
- B. Ground metallic cable shield with a cable shield grounding adapter, consisting of a solderless connector enclosed in watertight rubber housing covering the entire assembly, bleeder wire, and ground braid.

2.8 LOW-VOLTAGE EQUIPMENT

- A. Mount the low-voltage bushings, and hot stick in the low-voltage compartment.
- B. The low-voltage leads shall be brought out of the tank by epoxy pressure tight bushings, and shall be standard arrangement.
- C. Tin-plate the low-voltage neutral terminal and isolate from the transformer tank. Provide a removable ground strap sized in accordance with the NEC and connect between the secondary neutral and ground pad.

2.9 TRANSFORMERS

- A. Transformer ratings shall be as shown on drawings. kVA ratings shown on the drawings are for continuous duty without the use of cooling fans.
- B. Temperature rises shall not exceed the NEMA TR 1 of 65° C (149° F) by resistance.
- C. Transformer insulating material shall be less flammable, edible-seed-oil based, and UL listed as complying with NFPA 70 requirements for

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

fire point of not less than 300° C (600° F) when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.

- D. Transformer impedance shall be not less than 4-1/2% for sizes 150 kVA and larger. Impedance shall be as shown on the drawings.
- E. Sound levels shall conform to NEMA TR 1 standards.
- F. Primary and Secondary Windings for Three-Phase Transformers:
 - 1. Primary windings shall be delta-connected.
 - 2. Secondary windings shall be wye-connected, except where otherwise indicated on the drawings. Provide isolated neutral bushings for secondary wye-connected transformers.
 - 3. Secondary leads shall be brought out through pressure-tight epoxy bushings.
- G. Primary windings shall have four 2-1/2% full-capacity voltage taps; two taps above and two taps below rated voltage.
- H. Core and Coil Assemblies:
 - 1. Cores shall be grain-oriented, non-aging, silicon steel to minimize losses.
 - 2. Core and coil assemblies shall be rigidly braced to withstand the stresses caused by rough handling during shipment, and stresses caused by any possible short-circuit currents.
 - 3. Coils shall be continuous-winding type without splices except for taps. Material shall be copper.
 - 4. Coil and core losses shall be optimum for efficient operation.
 - 5. Primary, secondary, and tap connections shall be brazed or pressure type.
 - 6. Provide end fillers or tie-downs for coil windings.
- I. The transformer tank, cover, and radiator gauge thickness shall not be less than that required by ANSI.
- J. Accessories:
 - 1. Provide standard NEMA features, accessories, and the following:
 - a. No-load tap changer. Provide warning sign.
 - b. Lifting, pulling, and jacking facilities.
 - c. Globe-type valve for oil filtering and draining, including sampling device.
 - d. Pressure relief valve.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

- e. Liquid level gauge and filling plug.
- f. A grounding pad in the medium- and low-voltage compartments.
- g. A diagrammatic nameplate.
- h. Dial-type liquid thermometer with a maximum reading pointer and an external reset.
- i. Hot stick. Securely fasten hot stick within low-voltage compartment.
- 2. The accessories shall be made accessible within the compartments without disassembling trims and covers.
- K. Transformers shall meet the energy conservation standards for transformers per the United States Department of Energy 10 CFR Part 431.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install transformers outdoors, as shown on the drawings, in accordance with the NEC, and as recommended by the manufacturer.
- B. Anchor transformers with rustproof bolts, nuts, and washers not less than 12 mm (1/2 inch) diameter, in accordance with manufacturer's instructions, and as shown on drawings.
- D. Mount transformers on concrete slab. Unless otherwise indicated, the slab shall be at least 200 mm (8 inches) thick, reinforced with a 150 by 150 mm (6 by 6 inches) No. 6 mesh placed uniformly 100 mm (4 inches) from the top of the slab. Slab shall be placed on a 150 mm (6 inches) thick, well-compacted gravel base. The top of the concrete slab shall be approximately 100 mm (4 inches) above the finished grade. Edges above grade shall have 12-1/2 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at least 200 mm (8 inches) beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm (3 inches) above slab surface. Concrete work shall be as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.
- E. Grounding:
 - 1. Ground each transformer in accordance with the requirements of the NEC. Install ground rods per the requirements of Section 26 05 26,

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS, to maintain a maximum resistance of 5 ohms to ground.

2. Connect the ground rod to the ground pads in the medium- and low-voltage compartments.
3. Install and connect the cable shield grounding adapter per the manufacturer's instructions. Connect the bleeder wire of the cable shield grounding adapter to the loadbreak or deadbreak elbow grounding point with minimum No. 14 AWG wire, and connect the ground braid to the grounding system with minimum No. 6 AWG bare copper wire. Use soldered or mechanical grounding connectors listed for this purpose.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform manufacturer's required field tests in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:
 - a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical and mechanical condition. Check for damaged or cracked bushings and liquid leaks.
 - c. Verify that control and alarm settings on temperature indicators are as specified.
 - d. Inspect all field-installed bolted electrical connections, using the calibrated torque-wrench method to verify tightness of accessible bolted electrical connections, and perform thermographic survey after energization under load.
 - e. Vacuum-clean transformer interior. Clean transformer enclosure exterior.
 - f. Verify correct liquid level in transformer tank.
 - g. Verify correct equipment grounding per the requirements of Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
 - h. Verify the presence and connection of transformer surge arresters, if provided.
 - i. Verify that the tap-changer is set at rated system voltage.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

3.3 FOLLOW-UP VERIFICATION

- A. Upon completion of acceptance checks, settings, and tests, the Contractor shall demonstrate that the transformers are in good operating condition and properly performing the intended function.

3.4 SPARE PARTS NOT USED

3.5 INSTRUCTION

- A. The Contractor shall instruct maintenance personnel, for not less than one 2-hour period, on the maintenance and operation of the equipment on the date requested by the COR.

---END---

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

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11-01-22

SECTION 26 24 13
DISTRIBUTION SWITCHBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of the low-voltage circuit-breaker distribution switchboards, indicated as switchboard(s) in this section.

1.2 RELATED WORK

- A. Section 03 30 00, CAST-IN-PLACE CONCRETE: Requirements for concrete equipment pads.
- C. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- D. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.
- E. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible fault currents.
- F. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduit.
- G. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: Short circuit and coordination study, and requirements for a coordinated electrical system.
- H. Section 26 11 16, SECONDARY UNIT SUBSTATIONS: Switchboards as part of secondary unit substations.
- I. Section 26 25 11, BUSWAYS: Feeder busway and fittings.
- J. Section 26 43 13, SURGE PROTECTIVE DEVICES: Surge protective devices for switchboards.

1.3 QUALITY ASSURANCE

- A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

- A. Factory Tests shall be required.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

- B. Factory Tests shall be in accordance with Paragraph, MANUFACTURED PRODUCTS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirement:
1. Tests shall be conducted per NEMA PB 2.
 2. Verify that circuit breaker sizes and types correspond to drawings, and the Overcurrent Protective Device Coordination Study.
 3. Verify tightness of bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
 5. Exercise all active components.
 6. Perform an insulation-resistance test, phase to ground, on each bus section, with phases not under test grounded, in accordance with manufacturer's published data.
 7. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 V DC for 300-volt rated cable and 1000 V DC for 600-volt rated cable, or as required if solid-state components or control devices cannot tolerate the applied voltage.
 8. If applicable, verify correct function of control transfer relays located in the switchboard with multiple control power sources.
 9. Perform phasing checks on double-ended or dual-source switchboards to insure correct bus phasing from each source.

1.5 SUBMITTALS

- A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:
1. Shop Drawings:
 - a. Switchboard shop drawings shall be submitted simultaneously with or after the Overcurrent Protective Device Coordination Study.
 - b. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - c. Prior to fabrication of switchboards, submit the following data for approval:
 - 1) Complete electrical ratings.
 - 2) Circuit breaker sizes.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

- 3) Interrupting ratings.
- 4) Safety features.
- 5) Accessories and nameplate data.
- 6) Switchboard one line diagram, showing ampere rating, number of bars per phase and neutral in each bus run (horizontal and vertical), bus spacing, equipment ground bus, and bus material.
- 7) Elementary and interconnection wiring diagrams.
- 8) Technical data for each component.
- 9) Dimensioned exterior views of the switchboard.
- 10) Dimensioned section views of the switchboard.
- 11) Floor plan of the switchboard.
- 12) Foundation plan for the switchboard.
- 13) Provisions and required locations for external conduit and wiring entrances.
- 14) Approximate design weights.

2. Manuals:

- a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
 - 1) Schematic signal and control diagrams, with all terminals identified, matching terminal identification in the switchboard.
 - 2) Include information for testing, repair, trouble shooting, assembly, disassembly, and factory recommended/required periodic maintenance procedures and frequency.
 - 3) Provide a replacement and spare parts list. Include a list of tools and instruments for testing and maintenance purposes.
 - b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

- a. Certification by the manufacturer that the switchboards conform to the requirements of the drawings and specifications.
- b. Certification by the Contractor that the switchboards have been properly installed, adjusted, and tested.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.
- B. Institute of Engineering and Electronic Engineers (IEEE):
 - C37.13-15.....Low Voltage AC Power Circuit Breakers Used in Enclosures
 - C57.13-16.....Instrument Transformers
 - C62.41.1-08.....Surge Environment in Low-voltage (1000V and less) AC Power Circuits
 - C62.45-08.....Surge Testing for Equipment connected to Low-Voltage AC Power Circuits
- C. International Code Council (ICC):
 - IBC-21.....International Building Code
- D. National Electrical Manufacturer's Association (NEMA):
 - PB 2-11.....Deadfront Distribution Switchboards
 - PB 2.1-13.....Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less
- E. National Fire Protection Association (NFPA):
 - 70-23.....National Electrical Code (NEC)
- F. Underwriters Laboratories, Inc. (UL):
 - 67-18.....Panelboards
 - 489-16.....Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
 - 891-19.....Switchboards

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

PART 2 - PRODUCTS

2.1 GENERAL

- A. Shall be in accordance with IEEE, NEMA, NFPA, UL, as shown on the drawings, and have the following features:
1. Switchboard shall be a complete, grounded, continuous-duty, integral assembly, dead-front, dead-rear, self-supporting, indoor type switchboard assembly,. Incorporate devices shown on the drawings and all related components required to fulfill operational and functional requirements.
 2. Ratings shall not be less than shown on the drawings. Short circuit ratings shall not be less than the available fault current shown in the Overcurrent Protective Device Coordination Study.
 3. Switchboard shall conform to the arrangements and details shown on the drawings.
 6. Switchboards shall be assembled, connected, and wired at the factory so that only external circuit connections are required at the construction site. Split the structure only as required for shipping and installation. Packaging shall provide adequate protection against rough handling during shipment.
 7. All non-current-carrying parts shall be grounded per Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS for additional requirements.
 8. Series rated switchboards are not allowed.

2.2 BASIC ARRANGEMENT

- A. Type 1: Switchboard shall be front accessible with the following features:
1. Device mounting:
 - a. Main breaker: Individually mounted and compartmented or group mounted with feeder breakers.
 - b. Feeder breakers: Group mounted.
 2. Section alignment: As shown on the drawings.
 3. Accessibility:
 - a. Main section line and load terminals: Front and side.
 - b. Distribution section line and load terminals: Front.
 - c. Through bus connections: Front and end.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

4. Bolted line and load connections.
5. Full height wiring gutter covers for access to wiring terminals.

2.3 HOUSING

A. Shall have the following features:

1. Frames and enclosures:

- a. The assembly shall be braced with reinforcing gussets using bolted connections and jig welds as required to assure rectangular rigidity.
- b. The enclosure shall be steel, leveled, and not less than the gauge required by applicable publications.
- c. Die-pierce the holes for connecting adjacent structures to insure proper alignment, and to allow for future additions.
- d. All bolts, nuts, and washers shall be cadmium-plated steel.

B. Finish:

1. All metal surfaces shall be thoroughly cleaned, phosphatized and factory primed prior to applying baked enamel or lacquer finish.
2. Provide a light gray finish for indoor switchboard.

2.4 BUSES

A. Bus Bars and Interconnections:

1. Provide copper phase and neutral buses, fully rated for the amperage as shown on the drawings for the entire length of the switchboard. Bus laminations shall have a minimum of 6 mm (1/4 inch) spacing.
2. Mount the buses on appropriately spaced insulators and brace to withstand the available short circuit currents.
3. The bus and bus compartment shall be designed so that the acceptable NEMA standard temperature rises are not exceeded.
4. Install a copper ground bus the full length of the switchboard assembly.
5. Main Bonding Jumper: An un-insulated copper bus, size as shown on drawings, shall interconnect the neutral and ground buses, when the switchboard is used to establish the system common ground point.
6. All bolts, nuts, and washers shall be cadmium-plated steel. Bolts shall be torqued to the values recommended by the manufacturer.
7. Make provisions for future bus extensions by means of bolt holes or other approved method.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

2.5 MAIN CIRCUIT BREAKERS

- A. Type I or Type II Switchboards: Provide molded case main circuit breakers as shown on the drawings. Circuit breakers shall be the solid state adjustable trip type.
1. Trip units shall have field adjustable tripping characteristics as follows:
 - a. Long time pickup.
 - b. Long time delay.
 - c. Short time pickup.
 - d. Short time delay.
 - e. Instantaneous.
 2. Breakers with same frame size shall be interchangeable with each other.
 3. Drawout Mounting: Provide a racking mechanism to position and hold the breaker in the connected, test, or disconnected position. Provide an interlock to prevent movement of the breaker into or out of the connected position unless the breaker is tripped open.
 4. Trip Devices: Breakers shall be electrically and mechanically trip free and shall have trip devices in each pole. Unless otherwise indicated on drawings, each breaker shall have overcurrent and short-circuit trip devices. Trip devices shall be of the solid state type with adjustable pick-up settings, with both long time and short time elements, and integral trip unit testing provisions. Devices shall have time-delay band adjustment. Long-time delay element shall have inverse time characteristics. Main circuit breakers shall not have instantaneous trip function.
 5. Position Indicator: Provide a mechanical indicator visible from the front of the unit to indicate whether the breaker is open or closed.
 6. Trip Button: Equip each breaker with a mechanical trip button accessible from the front of the door.
 7. Padlocking: Provisions shall be included for padlocking the breaker in the open position.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

8. Operation: Unless otherwise indicated herein or on the drawings, breakers shall be manually operated. Breakers larger than 1600 ampere frame size shall be electrically operated.

2.6 FEEDER CIRCUIT BREAKERS

- A. Provide molded case circuit breakers as shown on the drawings.
- B. Non-adjustable Trip Molded Case Circuit Breakers:
1. Molded case circuit breakers shall have automatic, trip free, non-adjustable, inverse time characteristics, and instantaneous magnetic trip.
 2. Breaker features shall be as follows:
 - a. A rugged, integral housing of molded insulating material.
 - b. Silver alloy contacts.
 - c. Arc quenchers and phase barriers for each pole.
 - d. Quick-make, quick-break, operating mechanisms.
 - e. A trip element for each pole, thermal magnetic type with long time delay and instantaneous characteristics, a common trip bar for all poles and a single operator.
 - f. Electrically and mechanically trip free.
 - g. An operating handle which indicates ON, TRIPPED, and OFF positions.
 - h. Line and load connections shall be bolted.
 - i. An overload on one pole of a multipole breaker shall automatically cause all the poles of the breaker to open.
- C. Adjustable Trip Molded Case Circuit Breakers:
1. Provide molded case, solid state adjustable trip type circuit breakers.
 2. Trip units shall have field adjustable tripping characteristics as follows:
 - a. Long time pickup.
 - b. Long time delay.
 - c. Short time pickup.
 - d. Short time delay.
 - e. Instantaneous.
 3. Breakers with same frame size shall be interchangeable with each other.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

2.8 SURGE PROTECTIVE DEVICES

- A. Refer to Section 26 43 13, SURGE PROTECTIVE DEVICES.

2.9 METERING

- A. Refer to Section 25 10 10, ADVANCED UTILITY METERING. Refer to drawings for meter locations.
- B. Provide current transformers for each meter. Current transformers shall be wired to shorting-type terminal blocks.
- C. Provide voltage transformers including primary fuses and secondary protective devices for metering as shown on the drawings.

2.10 OTHER EQUIPMENT

- A. Furnish tools and accessories required for circuit breaker and switchboard test, inspection, maintenance, and proper operation.

2.11 CONTROL WIRING

- A. Switchboard control wires shall not be less than No. 14 AWG copper 600 volt rated. Install wiring complete at the factory, adequately bundled and protected. Provide separate control circuit fuses in each breaker compartment and locate for ease of access and maintenance.

2.12 NAMEPLATES AND MIMIC BUS

- A. Nameplates: For Normal Power system, provide laminated black phenolic resin with white core with 12 mm (1/2 inch) engraved lettered nameplates next to each circuit breaker. For Essential Electrical System, provide laminated red phenolic resin with white core with 12 mm (1/2 inch) engraved lettered nameplates next to each circuit breaker. Nameplates shall indicate equipment served, spaces, or spares in accordance with one line diagram shown on drawings. Nameplates shall be mounted with plated screws on front of breakers or on equipment enclosure next to breakers. Mounting nameplates only with adhesive is not acceptable.
- B. Mimic Bus: Provide an approved mimic bus on front of each switchboard assembly. Color shall be black for the Normal Power system and red for the Essential Electrical System, either factory-painted plastic or metal strips. Plastic tape shall not be used. Use symbols similar to one line diagram shown on drawings. Plastic or metal strips shall be mounted with plated screws.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install switchboards in accordance with the NEC, as shown on the drawings, and as recommended by the manufacturer.
- B. Anchor switchboards with rustproof bolts, nuts, and washers not less than 13 mm (1/2 inch) diameter, in accordance with manufacturer's instructions, and as shown on drawings.
- C. Interior Location. Mount switchboard on concrete slab. Unless otherwise indicated, the slab shall be at least 100 mm (4 inches) thick. The top of the concrete slab shall be approximately 100 mm (4 inches) above finished floor. Edges above floor shall have 12.5 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at least 200 mm (8 inches) beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm (3 inches) above slab surface. Concrete work shall be as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:
 - 1. Visual Inspection and Tests:
 - a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical, electrical, and mechanical condition.
 - c. Verify appropriate anchorage, required area clearances, and correct alignment.
 - d. Verify that circuit breaker sizes and types correspond to approved shop drawings.
 - e. Verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energization.
 - g. Vacuum-clean switchboard enclosure interior. Clean switchboard enclosure exterior.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

- h. Inspect insulators for evidence of physical damage or contaminated surfaces.
- i. Verify correct shutter installation and operation.
- j. Exercise all active components.
- k. Verify the correct operation of all sensing devices, alarms, and indicating devices.
- l. Verify that vents are clear.
- 2. Electrical tests:
 - a. Perform insulation-resistance tests on each bus section.
 - b. Perform insulation-resistance test on control wiring; do not perform this test on wiring connected to solid-state components.
 - c. Perform phasing check on double-ended switchboards to ensure correct bus phasing from each source.

3.3 FOLLOW-UP VERIFICATION

- A. Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that the switchboard is in good operating condition and properly performing the intended function.

3.4 WARNING SIGN NOT USED

3.5 ONE LINE DIAGRAM AND SEQUENCE OF OPERATION

- A. At final inspection, an as-built one line diagram shall be laminated or mounted under acrylic glass, and installed in a frame mounted in the switchboard room or in the outdoor switchboard enclosure.
- B. Furnish a written sequence of operation for the switchboard and connected line side/load side electrical distribution equipment. The sequence of operation shall be laminated or mounted under acrylic glass, and installed in a frame mounted in the switchboard room or in the outdoor switchboard enclosure.
- C. Deliver an additional four copies of the as-built one line diagram and sequence of operation to the COR.

3.6 AS-LEFT TRIP UNIT SETTINGS

- A. The trip unit settings shall be set in the field by an authorized representative of the switchboard manufacturer per the approved Electrical System Protective Device Study in accordance with Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

- C. Post a durable copy of the "as-left" trip unit settings in a convenient location in the switchboard room Deliver four additional copies of the settings to the COR. Furnish this information prior to the activation of the switchboard.

3.7 INSTRUCTION

- A. Furnish the services of a factory-trained technician for one, 4-hour training period for instructing personnel in the maintenance and operation of the switchboards, on the dates requested by the COR.

---END---

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

SECTION 26 24 16
PANELBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, and connection of panelboards.

1.2 RELATED WORK

- A. Section 09 91 00, PAINTING: Painting of panelboards.
- D. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:
Requirements that apply to all sections of Division 26.
- E. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES:
Low-voltage conductors.
- F. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- G. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.
- I. Section 26 09 23, LIGHTING CONTROLS: Lighting controls integral to panelboards.
- J. Section 26 43 13, SURGE PROTECTIVE DEVICES: Surge protective devices integral to panelboards.

1.3 QUALITY ASSURANCE

- A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:
1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Include electrical ratings, dimensions, mounting details, materials, required clearances, terminations, weight, circuit breakers, wiring and connection diagrams, accessories, and nameplate data.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

2. Manuals:
 - a. Submit, simultaneously with the shop drawings, complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering circuit breakers and replacement parts.
 - 1) Include schematic diagrams, with all terminals identified, matching terminal identification in the panelboards.
 - 2) Include information for testing, repair, troubleshooting, assembly, and disassembly.
 - b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
 - a. Certification by the manufacturer that the panelboards conform to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that the panelboards have been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. International Code Council (ICC):
IBC-15.....International Building Code
- C. National Electrical Manufacturers Association (NEMA):
PB 1-11.....Panelboards
250-14.....Enclosures for Electrical Equipment (1,000V Maximum)
- D. National Fire Protection Association (NFPA):
70-17.....National Electrical Code (NEC)
70E-18.....Standard for Electrical Safety in the Workplace
- E. Underwriters Laboratories, Inc. (UL):
50-15.....Enclosures for Electrical Equipment
67-09.....Panelboards

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

489-16.....Molded Case Circuit Breakers and Circuit
Breaker Enclosures

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Panelboards shall be in accordance with NEC, NEMA, UL, as specified, and as shown on the drawings.
- B. Panelboards shall have main breaker or main lugs, bus size, voltage, phases, number of circuit breaker mounting spaces, top or bottom feed, flush or surface mounting, branch circuit breakers, and accessories as shown on the drawings.
- C. Panelboards shall be completely factory-assembled with molded case circuit breakers and integral accessories as shown on the drawings or specified herein.
- D. Non-reduced size copper bus bars, rigidly supported on molded insulators, and fabricated for bolt-on type circuit breakers.
- E. Bus bar connections to the branch circuit breakers shall be the "distributed phase" or "phase sequence" type.
- F. Mechanical lugs furnished with panelboards shall be cast, stamped, or machined metal alloys listed for use with the conductors to which they will be connected.
- G. Neutral bus shall be 200% rated for all panels that provide UPS Power, mounted on insulated supports. Panels that are not UPS Power require 100% rated neutral busses.
- H. Grounding bus bar shall be equipped with screws or lugs for the connection of equipment grounding conductors.
- I. Bus bars shall be braced for the available short-circuit current as shown on the drawings, but not be less than 10,000 A symmetrical for 120/208 V and 120/240 V panelboards, and 14,000 A symmetrical for 277/480 V panelboards.
- J. In two-section panelboards, the main bus in each section shall be full size. The first section shall be furnished with subfeed lugs on the line side of main lugs only, or through-feed lugs for main breaker type panelboards, and have field-installed cable connections to the second section as shown on the drawings. Panelboard sections with tapped bus or crossover bus are not acceptable.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

K. Series-rated panelboards are not permitted.

2.2 ENCLOSURES AND TRIMS

A. Enclosures:

1. Provide galvanized steel enclosures, with NEMA rating as shown on the drawings or as required for the environmental conditions in which installed.
2. Enclosures shall not have ventilating openings.
3. Enclosures may be of one-piece formed steel or of formed sheet steel with end and side panels welded, riveted, or bolted as required.
4. Provide manufacturer's standard option for prepunched knockouts on top and bottom endwalls.
5. Include removable inner dead front cover, independent of the panelboard cover.

B. Trims:

1. Hinged "door-in-door" type.
2. Interior hinged door with hand-operated latch or latches, as required to provide access only to circuit breaker operating handles, not to energized parts.
3. Outer hinged door shall be securely mounted to the panelboard enclosure with factory bolts, screws, clips, or other fasteners, requiring a key or tool for entry. Hand-operated latches are not acceptable.
4. Inner and outer doors shall open left to right.
5. Trims shall be flush or surface type as shown on the drawings.

2.3 MOLDED CASE CIRCUIT BREAKERS

- A. Circuit breakers shall be per UL, NEC, as shown on the drawings, and as specified.
- B. Circuit breakers shall be bolt-on type.
- C. Circuit breakers shall have minimum interrupting rating as required to withstand the available fault current, but not less than:
 1. 120/208 V Panelboard: 10,000 A symmetrical.
 2. 120/240 V Panelboard: 10,000 A symmetrical.
 3. 277/480 V Panelboard: 14,000 A symmetrical.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

- D. Circuit breakers shall have automatic, trip free, non-adjustable, inverse time, and instantaneous magnetic trips for less than 400 A frame.
- E. Circuit breaker features shall be as follows:
1. A rugged, integral housing of molded insulating material.
 2. Silver alloy contacts.
 3. Arc quenchers and phase barriers for each pole.
 4. Quick-make, quick-break, operating mechanisms.
 5. A trip element for each pole, thermal magnetic type with long time delay and instantaneous characteristics, a common trip bar for all poles and a single operator.
 6. Electrically and mechanically trip free.
 7. An operating handle which indicates closed, tripped, and open positions.
 8. An overload on one pole of a multi-pole breaker shall automatically cause all the poles of the breaker to open.
 9. Ground fault current interrupting breakers, shunt trip breakers, lighting control breakers (including accessories to switch line currents), or other accessory devices or functions shall be provided where shown on the drawings.
 10. For circuit breakers being added to existing panelboards, coordinate the breaker type with existing panelboards. Modify the panel directory accordingly.

2.4 SURGE PROTECTIVE DEVICES

- A. Where shown on the drawings, furnish panelboards with integral surge protective devices. Refer to Section 26 43 13, SURGE PROTECTIVE DEVICES.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the manufacturer's instructions, the NEC, as shown on the drawings, and as specified.
- B. Locate panelboards so that the present and future conduits can be conveniently connected.
- D. Install a printed schedule of circuits in each panelboard after approval by the COR. Schedules shall reflect final load descriptions,

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

room numbers, and room names connected to each circuit breaker.

Schedules shall be printed on the panelboard directory cards and be installed in the appropriate panelboards

- E. Mount panelboards such that the maximum height of the top circuit breaker above the finished floor shall not exceed 1980 mm (78 inches).
- F. Provide blank cover for each unused circuit breaker mounting space.
- H. Rust and scale shall be removed from the inside of existing enclosures where new interior components are to be installed. Paint inside of enclosures with rust-preventive paint before the new interior components are installed. Provide new trim. Trim shall fit tight to the enclosure. Panelboard enclosures shall not be used for conductors feeding through, spliced, or tapping off to other enclosures or devices.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:
 - 1. Visual Inspection and Tests:
 - a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical, electrical, and mechanical condition.
 - c. Verify appropriate anchorage and required area clearances.
 - d. Verify that circuit breaker sizes and types correspond to approved shop drawings.
 - e. To verify tightness of accessible bolted electrical connections, use the calibrated torque-wrench method or perform thermographic survey after energization.
 - f. Vacuum-clean enclosure interior. Clean enclosure exterior.

3.3 FOLLOW-UP VERIFICATION

- A. Upon completion of acceptance checks, settings, and tests, the Contractor shall demonstrate that the panelboards are in good operating condition and properly performing the intended function.

---END---

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

SECTION 26 25 11
BUSWAYS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Busways will be installed above the cabinets in the Data Center to provide power to the cabinets. This section specifies the furnishing, installation, connection, and testing of busways for use in electrical systems rated 600 V and below.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:
Requirements that apply to all sections of Division 26.
- B. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.

1.3 QUALITY ASSURANCE

- A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:
1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Submit the following data for approval:
 - 1) Electrical ratings, dimensions, mounting details and position, mounting method, vertical supports, materials, fire stops, and weatherproofing.
 - 2) Detailed coordinated connections to equipment terminations such as switchgear, switchboards, and transformers.
 - 3) Coordination Drawings: Submit floor plans and sections, drawn to scale. Include bus assembly layouts and relationships between components and adjacent structural, mechanical, and electrical elements. Indicate vertical and horizontal

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

enclosed busway runs, offsets, transitions, and clearances for access above and to the side of enclosed busways. Indicate vertical elevation of busway above the floor or bottom of structure. Indicate support locations, type of support, and weight on each support.

2. Manuals:

a. Submit complete maintenance and operating manuals including technical data sheets, and information for ordering replacement parts.

1) Include information for testing, repair, troubleshooting, assembly, and disassembly.

b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.

3. Certifications: Two weeks prior to final inspection, submit the following.

a. Certification by the manufacturer that the busway conforms to the requirements of the drawings and specifications.

b. Certification by the Contractor that the busway has been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplement and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.

C. National Electrical Manufacturers Association (NEMA):

BU 1.1-10.....General Instructions for Handling,
Installation, Operation and Maintenance of
Busway Rated 600 Volts or Less

BU 1.2-13.....Application Information for Busway Rated 600
Volts or Less

D. National Fire Protection Association (NFPA):

70-17.....National Electrical Code (NEC)

E. Underwriters Laboratories Inc. (UL):

857-09.....Busways

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

PART 2 - PRODUCTS

2.1 MATERIAL

- A. Busway shall be in accordance with NEMA and UL.
- B. Busway shall be rated as shown on the drawings.
- C. Busway shall have the following features:
 - 1. For indoor locations; plug-intype, totally enclosed.
 - 3. Short circuit current rating shall not be less than 42,000 A, or as required to withstand the available fault current shown on the drawings, whichever is higher.
 - 4. 3-phase, 4-wire, with full 200% neutral, except where 3-phase, 3-wire is shown on the drawings.
 - 5. Internal 50%-rated ground bus bar. Busway housing is not allowed to serve as the equipment grounding conductor.
 - 6. All bus bars, phase, neutral, and ground, for each busway shall be within a single housing.
 - 7. Bus Bars:
 - a. Shall be full round edge rectangular copper of sufficient cross-section to provide full current rating without exceeding a temperature rise of 55° C above a 40° C ambient.
 - b. Interconnection joints shall be tin or silver plated, with steel bolts, nuts, and Belleville washers.
 - c. Shall be completely insulated with flame-retardant, track-resistant, self-extinguishing insulation.
 - 8. Housings:
 - a. Shall be steel or aluminum, with continuous mounting rails.
 - b. Shall be thoroughly cleaned and painted at the factory with primer and the manufacturer's standard finish.
 - c. Shall have rustproof metal hardware.
 - d. Provide external flanges and weatherproofing at busway entrances to buildings.
 - e. For busways that pass through fire-resistant rated construction, incorporate listed fire stops within the busway housings and external flanges.
 - f. Install expansion fittings in the busway runs in compliance with the manufacturer's standard recommendations.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

- g. The temperature rise at any point on the housing shall not exceed 30° C above an ambient temperature of 40° C.
9. Busway shall not be reduced in size at any point.
10. Provide manufacturer's fittings and accessories, including but not limited to elbows, tees, tap boxes, transformer taps, end boxes, expansion fittings, offsets, adapters, hangers, and mounting hardware.
- D. Dimensions and Configuration:
1. Configure within the space designated for busway installation.
 2. Coordinate busway routing with equipment installation by other trades to avoid conflicts.
 3. Make final field measurements and check them with the busway coordination drawings prior to authorization of fabrication of the busways.

2.2 PLUG-IN TYPE BUSWAY

- A. Plug-in busway shall be available in standard trade lengths, with plug-in openings provided on both sides of the busway sections. Plug-in covers shall prohibit dirt and debris from entering contact plug-in openings in the busway. The contact surfaces for bus plug stabs shall be tin- or silver-plated and of the same material, thickness, and rating as the phase bars. A standard housing ground connection shall be supplied in each plug-in opening.
- B. Plug-in units of the types and ratings indicated on the drawings and specifications shall be supplied. Plug-in units shall be mechanically interlocked with the busway housing to prevent their installation or removal while the switch is in the "ON" position. The enclosure of any plug-in unit shall make positive ground connection to the duct housing before the stabs make contact with the bus bars. All plug-in units shall be equipped with an interlock that can be defeated to prevent the cover from being opened while the plug-in unit is in the "ON" position, and to prevent accidental closing while the cover is open. The plug-in units shall be provided with a means for padlocking. The operating handle and mechanism shall remain in control of the plug-in unit at all times, permitting easy operation by means of a hook stick or chain. All plug-in units shall be interchangeable without alteration or modification of plug-in busway.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

- D. Circuit breaker-type plug-in units shall have an interrupting rating of not less than [_14,000_] symmetrical RMS amperes, as shown on the drawings. All circuit breaker plug-in devices shall be of the same manufacturer as the busway. Circuit breakers shall be as specified in Section 26 24 16, PANELBOARDS.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the NEC, as shown on the drawings, and manufacturer's instructions.
- B. Support busways as required by the NEC and as required by manufacturer's shop drawings.
- D. Coordinate all of the busway terminations to equipment to ensure proper phasing.
- E. Tighten bolted connections with a torque wrench to values as required by the manufacturer.
- F. Install expansion fittings at locations where busways cross building expansion joints. Install at other locations so distance between expansion fittings does not exceed manufacturer's recommended distance between fittings.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform manufacturer's required field tests in accordance with the manufacturer's recommendations. In addition, include the following:
1. Visual Inspection and Tests:
 - a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical, electrical, and mechanical condition.
 - c. Verify appropriate anchorage, required area clearances, and correct alignment.
 - d. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energization.
 - e. Verify appropriate equipment grounding.
 2. Electrical Tests:

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

- a. After installation, test busway phase-to-phase and phase-to-ground resistance with an insulation resistance tester.

Resulting values shall not be less than one megohm.

3.3 FOLLOW-UP VERIFICATION

- A. Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that the busway is in good operating condition and properly performing the intended function.
- B. After the busways have been energized for a minimum of 30 days, repeat the torque wrench tightening of all bolt connections.

---END---

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

SECTION 26 27 26
WIRING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of wiring devices.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one section of Division 26.
- B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Cables and wiring.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduit and boxes.
- E. Section 26 51 00, INTERIOR LIGHTING: Fluorescent ballasts and LED drivers for use with manual dimming controls.

1.3 QUALITY ASSURANCE

- A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:
1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Include electrical ratings, dimensions, mounting details, construction materials, grade, and termination information.
 2. Manuals:
 - a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

technical data sheets and information for ordering replacement parts.

- b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
 - a. Certification by the manufacturer that the wiring devices conform to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that the wiring devices have been properly installed and adjusted.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.
- B. National Electrical Manufacturers Association (NEMA):
 - WD 1-99(R2015).....General Color Requirements for Wiring Devices
 - WD 6-16 Wiring Devices - Dimensional Specifications
- C. National Fire Protection Association (NFPA):
 - 70-17.....National Electrical Code (NEC)
 - 99-18.....Health Care Facilities
- D. Underwriter's Laboratories, Inc. (UL):
 - 5-16.....Surface Metal Raceways and Fittings
 - 20-10.....General-Use Snap Switches
 - 231-16.....Power Outlets
 - 467-13.....Grounding and Bonding Equipment
 - 498-17.....Attachment Plugs and Receptacles
 - 943-16.....Ground-Fault Circuit-Interrupters
 - 1449-14.....Surge Protective Devices
 - 1472-15.....Solid State Dimming Controls

PART 2 - PRODUCTS

2.1 RECEPTACLES

- A. General: All receptacles shall comply with NEMA, NFPA, UL, and as shown on the drawings.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

1. Mounting straps shall be nickel plated brass, brass, nickel plated steel or galvanize steel with break-off plaster ears, and shall include a self-grounding feature. Terminal screws shall be brass, brass plated or a copper alloy metal.
2. Receptacles shall have provisions for back wiring with separate metal clamp type terminals (four minimum) and side wiring from four captively held binding screws.
- B. Duplex Receptacles - Hospital-grade: shall be listed for hospital grade, single phase, 20 ampere, 120 volts, 2-pole, 3-wire, NEMA 5-20R, with break-off feature for two-circuit operation.
 1. Bodies shall be RED FOR Emergency Power, ORANGE for UPS Power and ivory for Normal Power
 2. Switched duplex receptacles shall be wired so that only the top receptacle is switched. The lower receptacle shall be unswitched.
 3. Ground Fault Current Interrupter (GFCI) NOT USED
 4. Tamper-Resistant Duplex Receptacles: NOT USED
- C. Duplex Receptacles - Non-hospital Grade: shall be the same as duplex receptacles - hospital grade in accordance with sections 2.1A and 2.1B of this specification, except for the hospital grade listing.
- D. Receptacles - 20, 30, and 50 ampere, 250 Volts: Shall be complete with appropriate cord grip plug.

2.2 TOGGLE SWITCHES

- A. Toggle switches shall be totally enclosed tumbler type with nylon bodies. Handles shall be ivory in color unless otherwise specified or shown on the drawings.
 1. Switches installed in hazardous areas shall be explosion-proof type in accordance with the NEC and as shown on the drawings.
 2. Shall be single unit toggle, butt contact, quiet AC type, heavy-duty general-purpose use with an integral self grounding mounting strap with break-off plaster ears and provisions for back wiring with separate metal wiring clamps and side wiring with captively held binding screws.
 3. Switches shall be rated 20 amperes at 120-277 Volts AC.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

2.3 MANUAL DIMMING CONTROL (NOT USED)

2.4 WALL PLATES

- A. Wall plates for switches and receptacles shall be type 302 stainless steel. Oversize plates are not acceptable.
- C. For receptacles or switches mounted adjacent to each other, wall plates shall be common for each group of receptacles or switches.
- D. In areas requiring tamperproof wiring devices, wall plates shall be type 302 stainless steel, and shall have tamperproof screws and beveled edges.
- E. Duplex Receptacles on Emergency Circuit: Wall plates shall be red nylon with the word "EMERGENCY" engraved in 6 mm (1/4 inch) white letters. Wall plates shall be type 302 stainless steel, with the word "EMERGENCY" engraved in 6 mm (1/4 inch) red letters.

2.5 SURFACE MULTIPLE-OUTLET ASSEMBLIES NOT USED

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the NEC and as shown as on the drawings.
- B. Install wiring devices after wall construction and painting is complete.
- C. The ground terminal of each wiring device shall be bonded to the outlet box with an approved green bonding jumper, and also connected to the branch circuit equipment grounding conductor.
- D. Outlet boxes for toggle switches and manual dimming controls shall be mounted on the strike side of doors.
- E. Provide barriers in multi-gang outlet boxes to comply with the NEC.
- F. Coordinate the electrical work with the work of other trades to ensure that wiring device flush outlets are positioned with box openings aligned with the face of the surrounding finish material. Pay special attention to installations in cabinet work, and in connection with laboratory equipment.
- G. Exact field locations of floors, walls, partitions, doors, windows, and equipment may vary from locations shown on the drawings. Prior to locating sleeves, boxes and chases for roughing-in of conduit and

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-18

equipment, the Contractor shall coordinate exact field location of the above items with other trades.

- H. Install wall switches 1.2 M (48 inches) above floor, with the toggle OFF position down.
- I. Install wall dimmers 1.2 M (48 inches) above floor.
- J. Install receptacles 450 mm (18 inches) above floor, and 152 mm (6 inches) above counter backsplash or workbenches. Install specific-use receptacles at heights shown on the drawings.
- K. Install horizontally mounted receptacles with the ground pin to the right.
- L. When required or recommended by the manufacturer, use a torque screwdriver. Tighten unused terminal screws.
- M. Label device plates with a permanent adhesive label listing panel and circuit feeding the wiring device.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform manufacturer's required field checks in accordance with the manufacturer's recommendations, and the latest NFPA 99. In addition, include the following:
 - 1. Visual Inspection and Tests:
 - a. Inspect physical and electrical conditions.
 - b. Vacuum-clean surface metal raceway interior. Clean metal raceway exterior.
 - c. Test wiring devices for damaged conductors, high circuit resistance, poor connections, inadequate fault current path, defective devices, or similar problems using a portable receptacle tester. Correct circuit conditions, remove malfunctioning units and replace with new, and retest as specified above.
 - d. Test GFCI receptacles.
 - 2. Receptacle testing in the Patient Care Spaces, such as retention force of the grounding blade of each receptacle, shall comply with the latest NFPA 99.

---END---

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

SECTION 26 32 13
ENGINE GENERATORS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of the low-voltage engine generators.

1.2 RELATED WORK

- A. Section 03 30 00, CAST-IN-PLACE CONCRETE: Requirements for concrete equipment pads.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- C. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.
- D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- E. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: Short circuit and coordination study, and requirements for a coordinated electrical system.
- F. Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION: Requirements for hot piping and equipment insulation.
- G. Section 25 10 10, ADVANCED UTILITY METERING: Requirements for electrical metering.
- H. Section 26 23 13, GENERATOR PARALLELING CONTROLS ON SWITCHBOARD: Requirements for generator paralleling.
- I. Section 26 24 13, DISTRIBUTION SWITCHBOARDS: Requirements for secondary distribution switchboards
- J. Section 26 36 23, AUTOMATIC TRANSFER SWITCHES: Requirements for automatic transfer switches for use with engine generators.

1.3 QUALITY ASSURANCE

- A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

- B. A factory-authorized representative shall be capable of providing emergency maintenance and repairs at the project site within 4 hours maximum of notification.

1.4 FACTORY TESTS

- A. Factory Tests shall be required.
- B. Factory Tests shall be in accordance with Paragraph, MANUFACTURED PRODUCTS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirement:
1. Load Test: Shall include two hours while the engine generator is delivering 100% of the specified kW, and four hours while the engine generator is delivering 80% of the specified kW. During this test, record the following data at 20-minute intervals:

Time	Engine RPM	Oil Temperature Out
kW	Water Temperature In	Fuel Pressure
Voltage	Water Temperature Out	Oil Pressure
Amperes	Oil Temperature In	Ambient Temperature

2. Cold Start Test: Record time required for the engine generator to develop specified voltage, frequency, and kW load from a standstill condition with engine at ambient temperature.
3. The manufacturer shall furnish fuel, load banks, testing instruments, and all other equipment necessary to perform these tests.

1.5 SUBMITTALS

- A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:
1. Shop Drawings:
- a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Scaled drawings, showing plan views, side views, elevations, and cross-sections.
2. Diagrams:

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

- a. Control system diagrams, control sequence diagrams or tables, wiring diagrams, interconnections diagrams (between engine generators, automatic transfer switches, paralleling switchgear, local control cubicles, remote annunciator panels, and fuel storage tanks, as applicable), and other like items.
3. Technical Data:
 - a. Published ratings, catalog cuts, pictures, and manufacturer's specifications for engine generator, governor, voltage regulator, radiator, muffler, dampers, day tank, pumps, fuel tank, batteries and charger, jacket heaters, torsional vibration, and control and supervisory equipment.
 - b. Description of operation.
 - c. Short-circuit current capacity and sub-transient reactance.
 - d. Sound power level data.
 - e. Vibration isolation system performance data from no-load to full-load. This must include seismic qualification of the engine generator mounting, base, and vibration isolation.
4. Calculations:
 - a. Calculated performance derations appropriate to installed environment.
5. Manuals:
 - a. When submitting the shop drawings, submit complete maintenance and operating manuals, to include the following:
 - 1) Technical data sheets.
 - 2) Wiring diagrams.
 - 3) Include information for testing, repair, troubleshooting, and factory recommended periodic maintenance procedures and frequency.
 - 4) Provide a replacement and spare parts list. Include a list of tools and instruments for testing and maintenance purposes.
 - b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
6. Test Reports:
 - a. Submit certified factory test reports for approval.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

- b. Submit field test reports two weeks prior to the final inspection.
7. Certifications:
- a. Prior to fabrication of the engine generator, submit the following for approval:
 - 1) A certification in writing that an engine generator of the same model and configuration, with the same bore, stroke, number of cylinders, and equal or higher kW/kVA ratings as the proposed engine generator, has been operating satisfactorily with connected loads of not less than 75% of the specified kW/kVA rating, for not fewer than 2,000 hours without any failure of a crankshaft, camshaft, piston, valve, injector, or governor system.
 - 2) A certification in writing that devices and circuits will be incorporated to protect the voltage regulator and other components of the engine generator during operation at speeds other than the rated RPM while performing maintenance. Submit thorough descriptions of any precautions necessary to protect the voltage regulator and other components of the system during operation of the engine generator at speeds other than the rated RPM.
 - 3) A certification from the engine manufacturer stating that the engine exhaust emissions meet the applicable federal, state, and local regulations and restrictions. At a minimum, this certification shall include emission factors for criteria pollutants including nitrogen oxides, carbon monoxide, particulate matter, sulfur dioxide, non-methane hydrocarbon, and hazardous air pollutants (HPAs).
 - b. Prior to installation of the engine generator at the job site, submit certified factory test data.
 - c. Two weeks prior to the final inspection, submit the following.
 - 1) Certification by the manufacturer that the engine generators conform to the requirements of the drawings and specifications.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

- 2) Certification by the Contractor that the engine generators have been properly installed, adjusted, and tested.

1.6 STORAGE AND HANDLING

- A. Engine generators shall withstand shipping and handling stresses in addition to the electrical and mechanical stresses which occur during operation of the system. Protect radiator core with wood sheet.
- B. Store the engine generators in a location approved by the COR.

1.7 JOB CONDITIONS

- A. Job conditions shall conform to the arrangements and details shown on the drawings. The dimensions, enclosures, and arrangements of the engine generator system shall permit the operating personnel to safely and conveniently operate and maintain the system in the space designated for installation.

1.8 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. American Society of Testing Materials (ASTM):
- A53/A53M-20.....Standard Specification for Pipe, Steel, Black, and Hot-Dipped, Zinc Coated Welded and Seamless
- B88-20.....Specification for Seamless Copper Water Tube
- B88M-20.....Specification for Seamless Copper water Tube (Metric)
- D975-21.....Diesel Fuel Oils
- C. Institute of Electrical and Electronic Engineers (IEEE):
- C37.13-15.....Low Voltage AC Power Circuit Breakers Used In Enclosures
- C37.90.1-12.....Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
- D. International Code Council (ICC):
- IBC-21.....International Building Code
- E. International Organization for Standardization (ISO):

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

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11-01-22

8528-1-18.....Reciprocating Internal Combustion Engine-Driven
Alternate Current Generating Sets - Part 1:
Application, Ratings and Performance

F. National Electrical Manufacturers Association (NEMA):

ICS 6-93(R2016).....Enclosures
ICS 4-15.....Application Guideline for Terminal Blocks
MG 1-16.....Motor and Generators
MG 2-14.....Safety Standard and Guide for Selection,
Installation and Use of Electric Motors and
Generators
PB 2-11.....Dead-Front Distribution Switchboards
250-20.....Enclosures for Electrical Equipment (1000 Volts
Maximum)

G. National Fire Protection Association (NFPA):

30-21.....Flammable and Combustible Liquids Code
37-21.....Installations and Use of Stationary Combustion
Engine and Gas Turbines
70-23.....National Electrical Code (NEC)
99-21.....Health Care Facilities
110-22.....Standard for Emergency and Standby Power
Systems

H. Underwriters Laboratories, Inc. (UL):

50-15.....Enclosures for Electrical Equipment
142-19.....Steel Aboveground Tanks for Flammable and
Combustible Liquids
467-13.....Grounding and Bonding Equipment
489-16.....Molded-Case Circuit Breakers, Molded-Case
Switches and Circuit-Breaker Enclosures
508-18.....Industrial Control Equipment
891-19.....Switchboards
1236-15.....Battery Chargers for Charging Engine-Starter
Batteries
2085-97.....Insulated Aboveground Tanks for Flammable and
Combustible Liquids
2200-20.....Stationary Engine Generator Assemblies

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

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11-01-22

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. The engine generator system shall be in accordance with ASTM, ISO, NEMA, NFPA, UL, as shown on the drawings, and as specified herein.
- B. Provide a factory-assembled, wired (except for field connections), complete, fully automatic engine generator system, as well as all associate equipment and devices intended for the operating, control, monitoring, and remote manual stop functions.
- C. Engine Generator Parameter Schedule:
 - 1. Power Rating: Emergency Standby
 - 2. Voltage: 120/208V
 - 3. Rated Power: 1,250 kW 1,560_ kVA continuous)
 - 4. Power Factor: 0.8 lagging
 - 5. Engine Generator Application: parallel with utility source
 - 6. Fuel: diesel
 - 7. Voltage Regulation: + 2% (maximum) (No Load to Full Load)
(standalone applications)
 - 8. Phases: 3 Phase, Wye
 - 9. Each component of the engine generator system shall be capable of operating at 900_ feet) above sea level in a ventilated room which will have average ambient air temperature ranging from a minimum of (50 °F) in winter to maximum of (80 °F) in summer.
- D. Assemble, connect, and wire the engine generator at the factory so that only the external connections need to be made at the construction site.
- E. Engine Generator Unit shall be factory-painted with manufacturer's primer and standard finishes.
- F. Connections between components of the system shall conform to the recommendations of the manufacturer.
- G. Couplings, shafts, and other moving parts shall be enclosed and guarded. Guards shall be metal, ruggedly constructed, rigidly fastened, and readily removable for convenient servicing of the equipment without disassembling any pipes and fittings.
- H. Engine generator shall have the following features:
 - 1. Factory-mounted on a common, rigid, welded, structural steel base.

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

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2. Engine generator shall be statically and dynamically balanced so that the maximum vibration in the horizontal, vertical, and axial directions shall be limited to 0.15 mm (0.0059 inch), with an overall velocity limit of 24 mm/sec (0.866 inch per second) RMS, for all speeds.
3. The isolators shall be constrained with restraints capable of withstanding static forces in any direction equal to twice the weight of the supported equipment.
4. Shall be capable of operating satisfactorily as specified for not fewer than 10,000 hours between major overhauls.

I. Each engine generator specified for parallel operation shall be configured for automatic parallel operation.

2.2 ENGINE

- A. The engine shall be coupled directly to a generator.
- B. Minimum four cylinders.
- C. The engine shall be able to start in a 4.5 °C (40 °F) ambient temperature while using No. 2 diesel fuel oil without the use of starting aids such as glow plugs and ether injections.
- D. The engine shall be equipped with electric heater for maintaining the coolant temperature between 32-38 °C (90-100 °F), or as recommended by the manufacturer.
 1. Install thermostatic controls, contactors, and circuit breaker-protected circuits for the heaters.
 2. The heaters shall operate continuously except while the engine is operating or the water temperature is at the predetermined level.

2.3 GOVERNOR

- A. Isochronous, electronic type.
- B. Steady-state speed band at 60 Hz shall not exceed plus or minus 0.33%.

2.4 LUBRICATION OIL SYSTEM

- A. Pressurized type.
- B. Positive-displacement pump driven by engine crankshaft.
- C. Full-flow strainer and full-flow or by-pass filters.
- D. Filters shall be cleanable or replaceable type and shall remove particles as small as 3 microns without removing the additives in the

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oil. For by-pass filters, flow shall be diverted without flow interruption.

- E. Extend lube oil sump drain line out through the skid base and terminate it with a drain valve and plug.

2.5 FUEL SYSTEM

- A. Main fuel storage tank(s) shall comply with the requirements of Section 23 10 00, FACILITY FUEL SYSTEMS.

- B. Shall comply with NFPA 37 and NFPA 30, and have the following features:

1. Injection pump(s) and nozzles.
2. Plungers shall be carefully lapped for precision fit and shall not require any packing.
3. Filters or screens that require periodic cleaning or replacement shall not be permitted in the injection system assemblies.
4. Return surplus oil from the injectors to the main storage tank by gravity or a pump.
5. Filter System:
 - a. Dual primary filters shall be located between the main fuel oil storage and day tank.
 - b. Secondary filters (engine-mounted) shall be located such that the oil will be thoroughly filtered before it reaches the injection system assemblies.
 - c. Filters shall be cleanable or replaceable type and shall entrap and remove water from oil as recommended by the engine manufacturer.

- C. Day Tank:

1. Each engine generator shall be provided with a welded steel separate self-supporting day tank with double-wall fuel containment.
2. Each day tank shall have capacity to supply fuel to the engine for a 4-hour period at 100% rated load without being refilled, including fuel that is returned to the main fuel storage tank. The calculation of the capacity of each day tank shall incorporate the requirement to stop the supply of fuel into the day tank at 90% of the ultimate volume of the tank.
3. Secure, pipe, and connect the tank adequately for maximum protection from fire hazards, including oil leaks.

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

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4. Incorporate a vent, drain cock, shutoff cocks, and gauge glass.
Terminate the vent piping outdoors with mushroom vent cap.
 5. Incorporate a float switch on the day tank to control the fuel oil transfer pump and to actuate an alarm in the engine generator control cubicle when the oil level in the tank drops below the level at which the transfer pump should start to refill the tank.
 - a. The float switch contacts controlling the fuel oil transfer pump shall be set to energize the pump when the liquid level in the tank reaches one-third of the total volume of the tank.
 - b. The float switch contacts that actuate the low fuel oil day tank alarm device shall be set to alarm and energize the second fuel transfer pump when the liquid level in the tank reaches one-quarter of the total volume of the tank.
 6. Day tank and engine supply line elevations shall be below the elevation of the injector return outlet on the engine.
- D. Fuel Transfer Pump - Main Storage Tank to Day Tank(s):
1. Electric motor-driven, duplex arrangement, close-coupled, single-stage, positive-displacement type with built-in pressure relief valves. When the fuel is used for cooling components of the fuel injection system, the engine's fuel return line shall be returned to the main storage tank, rather than the day tank.
 2. Include a heavy-duty automatic alternator and H-O-A switch to alternate sequence of pumps. Pumps shall be controlled with the float switch on the day tank and H-O-A selector switch such that the day tank will be refilled automatically when the oil level lowers to the low limit for the float switch. The H-O-A selector switches shall enable the pumps to be operated manually at any time.
 3. For all engines, the related transfer pump and its electrical and plumbing connections shall be sized to provide a flow rate of at least four times the engine's fuel pumping rate.
 4. Provide a manually-operated, rotary-type transfer pump connected in parallel with the electric motor-driven transfer pumps so that oil can be pumped to the day tank while the electric motor-driven pumps are inoperative.

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

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E. Piping System: Black steel standard weight ASTM A-53 pipe and necessary valves and pressure gauges between:

1. The engine and the day tank as shown on the drawings.
2. The day tank and the supply and return connections at the underground storage tank as shown on the drawings. Connections at the engine shall be made with flexible piping suitable for the fuel furnished.

2.6 COOLING SYSTEM

- A. Liquid-cooled, closed loop, with fin-tube remote radiator, and integral engine driven circulating pump, as shown on the drawings.
- B. Cooling capacity shall not be less than the cooling requirements of the engine generator and its lubricating oil while operating continuously at 100% of its specified rating.
- C. Water circulating pumps shall be the centrifugal type driven by engine. Incorporate pressure relief devices where required to prevent excessive pressure increase after the engine stops.
- D. Coolant shall be extended-life antifreeze solution, 50% ethylene glycol and 50% soft water, with corrosion inhibitor additive as recommended by the manufacturer.
- E. Fan shall be driven by a totally enclosed electric motor.
- F. Coolant hoses shall be flexible, per manufacturer's recommendation.
- G. Self-contained thermostatic-control valve shall modulate coolant flow to maintain optimum constant coolant temperature, as recommended by the engine manufacturer.
- H. Motor-Operated Dampers:
 1. Dampers, which are provided under Section 23 31 00, HVAC DUCTS AND CASINGS, shall be two-position, electric motor-operated.
 2. Dampers shall open simultaneously with the starting of the diesel engine and shall close simultaneously with the stopping of the diesel engine.
- I. Remote Radiator Enclosure:
 1. Shall be rugged, tamperproof assemblies framed with steel channels, angles, and braces. Provide fan shroud, fixed louvers, and bird screens at both air intake and exhaust.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

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11-01-22

2. Shall be securely bolted together to facilitate future dismantling.
Carriage type bolts shall be used with the washers and locknuts on the inside of the enclosures.
4. Anchor the enclosures to concrete bases with bolts, not less than 15 mm (0.5 inch) diameter.
5. Radiator fan motor shall be totally enclosed with guarded V-belt drive and an adjustable mounting base.
6. Coolant piping shall be as recommended by the manufacturer.

2.7 AIR INTAKE AND EXHAUST SYSTEMS

A. Air Intake:

1. Provide an engine-mounted air cleaner with replaceable dry filter and dirty filter indicator.

B. Exhaust System:

1. Where a turbocharger is required, they shall be engine-mounted, driven by the engine gases, securely braced against vibration and adequately lubricated by the engine's filtered lubrication system.

2. Exhaust Muffler:

Shall be critical grade type and capable of the following noise attenuation:

Octave Band Hertz (Mid Frequency)	Minimum db Attenuation (.0002 Microbar Reference)
31	5
63	10
125	27
500	37
1000	31
2000	26
4000	25
8000	26

3. Pressure drop in the complete exhaust system shall be small enough for satisfactory operation of the engine generator while it is delivering 100% of its specified rating.
4. Exhaust pipe size from the engine to the muffler shall be as recommended by the engine manufacturer. Pipe size from muffler to

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

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11-01-22

- air discharge shall be two pipe sizes larger than engine exhaust pipe.
5. Connections at the engine exhaust outlet shall be made with a flexible exhaust pipe. Provide bolted type pipe flanges welded to each end of the flexible section.
- C. Condensate drain at muffler shall be made with schedule 40 black steel pipe through a petcock.
- D. Exhaust Piping and Supports: Black steel pipe, ASTM A-53 standard weight with welded fittings. Spring type hangers, as specified in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT, shall support the pipe.
- E. Insulation for Exhaust Pipe and Muffler:
1. Calcium silicate minimum 75 mm (3 inches) thick.
 2. Insulation shall be as specified in Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION.
 3. The installed insulation shall be covered with aluminum jacket 0.4 mm (0.016 inch) thick. The jacket is to be held in place by bands of 0.38 mm (0.015 inch) thick by 15 mm (0.5 inch) wide aluminum.
 4. Insulation and jacket are not required on flexible exhaust sections.
- F. Wall Sleeves: Pipe sleeves (thimble) shall be Schedule 40 standard weight steel pipe. Flash exhaust pipe thimble through roof with 16 oz soft sheet copper, flanged, and made watertight under built-up roofing and extended up around pipe thimble. The exhaust pipe shall be positioned within the thimble by four 150 mm (6 inches) wide spiders welded to the exhaust pipe.
- G. Vertical exhaust piping shall be provided with a hinged, gravity-operated, self-closing rain cover.

2.8 ENGINE STARTING SYSTEM

- A. The engine starting system shall start the engine at any position of the flywheel.
- B. Electric cranking motor:
1. Shall be engine-mounted.
 2. Shall crank the engine via a gear drive.
 3. Rating shall be adequate for cranking the cold engine at the voltage provided by the battery system, and at the required RPM during five

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

consecutive starting attempts of 10 seconds cranking each at 10-second intervals, for a total of 50 seconds of actual cranking without damage (the fifth starting attempt will be manually initiated upon failure of a complete engine cranking cycle).

C. Batteries shall be lead-acid high discharge rate type.

1. Each battery cell shall have minimum and maximum electrolyte level indicators and a flip-top flame arrestor vent cap.
2. Batteries shall have connector covers for protection against external short circuits.
3. With the charger disconnected, the batteries shall have sufficient capacity so that the total system voltage does not fall below 85% of the nominal system voltage with the following demands:
Five consecutive starting attempts of 10 seconds cranking at 10 second intervals for a total of 50 seconds of actual cranking (the fifth starting attempt will be manually initiated upon failure of a complete engine cranking cycle).
4. Battery racks shall be metal with an alkali-resistant finish and thermal insulation, and secured to the floor.

D. Battery Charger:

1. A current-limiting battery charger, conforming to UL 1236, shall be provided and shall automatically recharge the batteries. The charger shall be capable of an equalize-charging rate for recharging fully depleted batteries within 24 hours and a floating charge rate for maintaining the batteries at fully charged condition.
2. An ammeter shall be provided to indicate charging rate. A voltmeter shall be provided to indicate charging voltage.

2.9 LUBRICATING OIL HEATER

- A. Provide a thermostatically-controlled electric heater to automatically maintain the oil temperature within plus or minus 1.7 °C (3 °F) of the control temperature.

2.10 JACKET COOLANT HEATER

- A. Provide a thermostatically-controlled electric heater mounted in the engine coolant jacketing to automatically maintain the coolant within plus or minus 1.7 °C (3 °F) of the temperature recommended by the

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

engine manufacturer to meet the starting time specified at the minimum winter outdoor temperature.

2.11 GENERATOR

- A. Synchronous, amortisseur windings, bracket-bearing, self-venting, rotating-field type connected directly to the engine.
- B. Lifting lugs designed for convenient connection to and removal from the engine.
- C. Integral poles and spider, or individual poles dove-tailed to the spider.
- D. Designed for sustained short-circuit currents in conformance with NEMA Standards.
- E. Designed for sustained operation at 100% of the RPM specified for the engine generator without damage.
- F. Telephone influence factor shall conform to NEMA MG 1.
- G. Furnished with brushless excitation system or static-exciter-regulator assembly.
- H. Nameplates attached to the generator shall show the manufacturer's name, equipment identification, serial number, voltage ratings, field current ratings, kW/kVA output ratings, power factor rating, time rating, temperature rise ratings, RPM ratings, full load current rating, number of phases and frequency, and date of manufacture.
- I. The grounded (neutral) conductor shall be electrically isolated from equipment ground and terminated in the same junction box as the phase conductors.

2.12 GENERATOR OVERCURRENT AND FAULT PROTECTION

- B. Generator circuit breaker shall be molded-case, electronic-trip type, and 100% rated, complying with UL 489. Tripping characteristics shall be adjustable long-time and short-time delay and instantaneous. Provide shunt trip to trip breaker when engine generator is shut down by other protective devices.
- F. Overcurrent protective device cubicle shall contain terminations for neutral and equipment grounding conductors as necessary.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

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11-01-22

2.13 CONTROLS

- A. Shall include Engine Generator Control Cubicle(s).
- B. General:
 - 1. Control equipment shall be in accordance with UL 508, NEMA ICS-4, ICS-6, and ANSI C37.90.1.
 - 2. Panels shall be in accordance with UL 50.
 - 3. Cubicles shall be in accordance with UL 891.
 - 4. Coordinate controls with the automatic transfer switches shown on the drawings so that the systems will operate as specified.
 - 5. Cubicles:
 - a. Code gauge steel: manufacturer's recommended heavy gauge steel with factory primer and light gray finish.
 - b. Doors shall be gasketed, attached with concealed or semi-concealed hinges, and shall have a permanent means of latching in closed position.
 - c. Panels shall be wall-mounted or incorporated in other equipment as indicated on the drawings or as specified.
 - d. Door locks for panels and cubicles shall be keyed identically to operate from a single key.
 - 6. Wiring: Insulated, rated at 600 V.
 - a. Install the wiring in vertical and horizontal runs, neatly harnessed.
 - b. Terminate all external wiring at heavy duty, pressure-type, terminal blocks.
 - 7. The equipment, wiring terminals, and wires shall be clearly and permanently labeled.
 - 8. The appropriate wiring diagrams shall be laminated or mounted under plexiglass within the frame on the inside of the cubicles and panels.
 - 9. All indicating lamps and switches shall be accessible and mounted on the cubicle doors.
 - 10. Meters shall be per the requirements of Section 25 10 10, ADVANCED UTILITY METERING.
 - 11. The manufacturer shall coordinate the interconnection and programming of the generator controls with all related equipment,

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

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11-01-22

including automatic transfer switches and generator paralleling controls as applicable, specified in other sections.

C. Engine generator Control Cubicle:

1. Starting and Stopping Controls:

- a. A three-position, maintained-contact type selector switch with positions marked "AUTOMATIC," "OFF," and "MANUAL." Provide flashing amber light for OFF and MANUAL positions.
- b. A momentary contact push-button switch with positions marked "MANUAL START" and "MANUAL STOP."
- c. Selector switch in AUTOMATIC position shall cause the engine to start automatically when a single pole contact in a remote device closes. When the generator's output voltage increases to not less than 90% of its rated voltage, and its frequency increases to not less than 58 Hz, the remote devices shall transfer the load to the generator. An adjustable time delay relay, in the 0 to 15 minute range, shall cause the engine generator to continue operating without any load after completion of the period of operation with load. Upon completion of the additional 0 to 15 minute (adjustable) period, the engine generator shall stop.
- d. Selector switch in OFF position shall prevent the engine from starting either automatically or manually. Selector switch in MANUAL position shall also cause the engine to start when the manual start push-button is depressed momentarily.
- e. With selector switch is in MANUAL position, depressing the MANUAL STOP push-button momentarily shall stop the engine after a cool-down period.
- f. A maintained-contact, red mushroom-head push-button switch marked "EMERGENCY STOP" will cause the engine to stop without a cool-down period, independent of the position of the selector switch.

2. Engine Cranking Controls:

- a. The cranking cycles shall be controlled by a timer that will be independent of the battery voltage fluctuations.
- b. The controls shall crank the engine through one complete cranking cycle, consisting of four starting attempts of 10 seconds each with 10 seconds between each attempt.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

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11-01-22

- c. Total actual cranking time for the complete cranking cycle shall be 40 seconds during a 70-second interval.
 - d. Cranking shall terminate when the engine starts so that the starting system will not be damaged. Termination of the cranking shall be controlled by self-contained, speed-sensitive switch. The switch shall prevent re-cranking of the engine until after the engine stops.
 - e. After the engine has stopped, the cranking control shall reset.
3. Supervisory Controls:
- a. Overcrank:
 - 1) When the cranking control system completes one cranking cycle (four starting attempts), without starting the engine, the OVERCRANK signal light and the audible alarm shall be energized.
 - 2) The cranking control system shall lock-out, and shall require a manual reset.
 - b. Coolant Temperature:
 - 1) When the temperature rises to the predetermined first stage level, the HIGH COOLANT TEMPERATURE - FIRST STAGE signal light and the audible alarm shall be energized.
 - 2) When the temperature rises to the predetermined second stage level, which shall be low enough to prevent any damage to the engine and high enough to avoid unnecessary engine shutdowns, the HIGH COOLANT TEMPERATURE - SECOND STAGE signal light and the audible alarm shall be energized and the engine shall stop.
 - 3) The difference between the first and second stage temperature settings shall be approximately -12 °C (10 °F).
 - 4) Permanently indicate the temperature settings near the associated signal light.
 - 5) When the coolant temperature drops to below 21 °C (70 °F), the "LOW COOLANT TEMPERATURE" signal light and the audible alarm shall be energized.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

- c. Low Coolant Level: When the coolant level falls below the minimum level recommended by the manufacturer, the LOW COOLANT LEVEL signal light and audible alarm shall be energized.
- d. Lubricating Oil Pressure:
- 1) When the pressure falls to the predetermined first stage level, the OIL PRESSURE - FIRST STAGE signal light and the audible alarm shall be energized.
 - 2) When the pressure falls to the predetermined second stage level, which shall be high enough to prevent damage to the engine and low enough to avoid unnecessary engine shutdowns, the OIL PRESSURE - SECOND STAGE signal light and the audible alarm shall be energized and the engine shall stop.
 - 3) The difference between the first and second stage pressure settings shall be approximately 15% of the oil pressure.
 - 4) The pressure settings near the associated signal light shall be permanently displayed so that the running oil pressure can be compared to the target (setpoint) value.
- e. Overspeed:
- 1) When the engine RPM exceeds the maximum RPM recommended by the manufacturer of the engine, the engine shall stop.
 - 2) Simultaneously, the OVERSPEED signal light and the audible alarm shall be energized.
- f. Low Fuel - Day Tank:
- When the fuel oil level in the day tank decreases to less than the level at which the fuel oil transfer pump should start to refill the tank, the LOW FUEL DAY TANK light and the audible alarm shall be energized.
- g. Low Fuel - Main Storage Tank:
- When the fuel oil level in the storage tank decreases to less than one-third of total tank capacity, the LOW FUEL-MAIN STORAGE TANK signal light and audible alarm shall be energized.
- h. Reset Alarms and Signals:
- Overcrank, Coolant Temperature, Coolant Level, Oil Pressure, Overspeed, and Low Fuel signal lights and the associated audible alarms shall require manual reset. A momentary-contact silencing

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

switch and push-button shall silence the audible alarm by using relays or solid state devices to seal in the audible alarm in the de-energized condition. Elimination of the alarm condition shall automatically release the sealed-in circuit for the audible alarm so that it will be automatically energized again when the next alarm condition occurs. The signal lights shall require manual reset after elimination of the condition which caused them to be energized. Install the audible alarm just outside the engine generator room in a location as directed by the COR. The audible alarm shall be rated for 85 dB at 3 M (10 feet).

i. Generator Breaker Signal Light:

- 1) A flashing green light shall be energized when the engine generator circuit breaker is in the OPEN or TRIPPED position.
- 2) Simultaneously, the audible alarm shall be energized.

4. Monitoring Devices:

- a. Electric type gauges for the cooling water temperatures and lubricating oil pressures. These gauges may be engine mounted with proper vibration isolation.
- b. A running time indicator, totalizing not fewer than 9,999 hours, and an electric type tachometer.
- c. A voltmeter, ammeter, frequency meter, kilowatt meter, manual adjusting knob for the output voltage, and the other items shown on the drawings shall be mounted on the front of the generator control panels.
- d. Install potential and current transformers as required.
- e. Visual Indications:
 - 1) OVERCRANK
 - 2) HIGH COOLANT TEMPERATURE - FIRST STAGE
 - 3) HIGH COOLANT TEMPERATURE - SECOND STAGE
 - 4) LOW COOLANT TEMPERATURE
 - 5) OIL PRESSURE - FIRST STAGE
 - 6) OIL PRESSURE - SECOND STAGE
 - 7) LOW COOLANT LEVEL
 - 8) GENERATOR BREAKER
 - 9) OVERSPEED

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

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11-01-22

10) LOW FUEL - DAY TANK

11) LOW FUEL - MAIN STORAGE TANK

f. Lamp Test: The LAMP TEST momentary contact switch shall momentarily actuate the alarm buzzer and all the indicating lamps.

5. Automatic Voltage Regulator:

- a. Shall correct voltage fluctuations rapidly and restore the output voltage to the predetermined level with a minimum amount of hunting.
- b. Shall include voltage level rheostat located inside the control cubicle.
- c. Provide a 3-phase automatic voltage regulator immune to waveform distortion.

2.14 REMOTE MANUAL STOP STATION. EXISTING EPO LOCATED BY EXIT DOOR

- A. Shall be provided per NFPA 101, and shall be a red mushroom-head push-button switch.
- B. Shall be connected to the main generator control panel to provide emergency shutdown of the generator.
- C. Shall be located outside the room housing the generator.
- D. Shall have permanent label reading "EMERGENCY STOP".

2.16 SOUND-ATTENUATED ENCLOSURE NOT USED

2.17 SPARE PARTS

- A. For each engine generator:
 - 1. Six lubricating oil filters.
 - 2. Six primary fuel oil filters.
 - 3. Six secondary fuel oil filters.
 - 4. Six intake air filters.
- B. For each battery charger:
 - 1. Three complete sets of fuses.
- C. For each control panel:
 - 1. Three complete sets of fuses, if applicable.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install concrete bases of dimensions shown on the drawings.

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01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

B. Installation of the engine generator shall comply with manufacturer's written instructions and with NFPA 110.

C. Mounting:

1. Support the base of engine generator on vibration isolators, each isolator bolted to the floor (pad), and the generator base bolted to isolator.
2. Install sufficient isolators so that the floor (pad) bearing pressure under each isolator is within the floor (pad) loading specification.
3. Install equal number of isolators on each side of the engine generator's base.
4. Locate isolators for approximately equal load distribution and deflection per isolator. The base of the engine generator shall be drilled at the factory for the isolator bolts.
5. Isolators shall be shipped loose with the engine generator.
6. All connections between the engine generator and exterior systems, such as fuel lines, electrical connections, and engine exhaust system and air exhaust shroud, shall be flexible.

E. Balance:

1. The vibration velocity in the horizontal, vertical, and axial directions shall not exceed 16.25 mm (0.65 inch) per second peak at any specific frequency. These limits apply to main structural components such as the engine block and the generator frame at the bearings.

F. Connect all components of the generator system so that they will continue to be energized during failure of the normal electrical power supply system.

G. Install piping between engine generator and remote components of cooling, fuel, and exhaust systems.

H. Flexible connection between radiator and exhaust shroud at the wall damper:

1. Install noncombustible flexible connections made of 20-oz neoprene-coated fiberglass fabric approximately 150 mm (6 inches) wide.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

2. Crimp and fasten the fabric to the sheet metal with screws 50 mm (2 inches) on center. The fabric shall not be stressed, except by the air pressure.

I. Exhaust System Insulation:

1. Adhesive and insulation materials shall be applied on clean, dry surfaces from which loose scale and construction debris has been removed by wire brushing.
2. Fill all cracks, voids, and joints of applied insulation material with high temperature 1093 °C (2000 °F) insulating cement before applying the outer covering.
3. The installation shall be clean and free of debris, thermally and structurally tight without sag, neatly finished at all hangers or other penetrations, and shall provide a smooth finished surface.
4. Insulation and jacket shall terminate hard and tight at all anchor points.
5. Insulate completely from engine exhaust flexible connection through roof or wall construction, including muffler.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Provide the services of a factory-authorized, factory-trained representative of the engine generator manufacturer to inspect field-assembled components and equipment installation, and to supervise the field tests.
- B. When the complete engine generator system has been installed and prior to the final inspection, test all components of the system in the presence of the COR for proper operation of the individual components and the complete system and to eliminate electrical and mechanical defects.
- C. Furnish fuel oil, lubricating oil, anti-freeze liquid, water treatment, rust-inhibitor, and load bank for testing of the engine generator.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

- D. Visual Inspection: Visually verify proper installation of engine generator and all components per manufacturer's pre-functional installation checklist.
- E. Set engine generator circuit breaker protective functions per Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY.
- F. Field Tests:
1. Perform manufacturer's after-starting checks and inspections.
 2. Test the engine generator for six hours of continuous operation as follows:
 - a. Two hours while delivering 100% of the specified kW.
 - b. Four hours while the engine generator is delivering 80% of its specified kW rating.
 - c. If during the 6-hour continuous test, an engine generator failure occurs or the engine generator cannot maintain specified power output, the test(s) are null and void. After repair and/or adjustments, the test(s) shall be repeated at no additional cost to the Government until satisfactory results are attained.
 3. Record the following test data at 30-minute intervals:
 - a. Time of day, as well as reading of running time indicator.
 - b. kW.
 - c. Voltage on each phase.
 - d. Amperes on each phase.
 - e. Engine RPM.
 - f. Frequency.
 - g. Coolant water temperature.
 - h. Fuel pressure.
 - i. Oil pressure.
 - j. Outdoor temperature.
 - k. Average ambient temperature in the vicinity of the engine generator.
 4. Demonstrate that the engine generator will attain proper voltage and frequency within the specified time limit from a cold start after the closing of a single contact.
 5. Furnish a resistance-type load for the testing of the engine generator. Test loads shall always include adequate resistance to

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-22

assure stability of the loads and equipment during all of the testing operations. The test load kW rating shall not be less than 100% of the specified kW rating of the engine generator.

G. Starting System Test:

1. Demonstrate that the batteries and cranking motor are capable of five starting attempts of 10 seconds cranking each at 10-second

I. Fuel systems shall be flushed and tested per Section 23 10 00, FACILITY FUEL SYSTEMS: Fuel supply and storage requirements.

J. Automatic Operation Tests:

Test the engine generator and associated automatic transfer switches to demonstrate automatic starting, loading and unloading. The load for this test shall be the actual connected loads. Initiate loss of normal source and verify the specified sequence of operation. Restore the normal power source and verify the specified sequence of operation. Verify resetting of controls to normal.

3.3 FOLLOW-UP VERIFICATION

- A. After completion of acceptance checks, settings, and tests, the Contractor shall demonstrate that the engine generator(s) and control and annunciation components are in good operating condition and properly performing the intended function.

3.4 INSTRUCTIONS AND FINAL INSPECTIONS

- A. Laminate or mount under acrylic resin a set of operating instructions for the system and install instructions within a frame mounted on the wall near the engine generator at a location per the COR.
- B. Furnish the services of a competent and factory-trained technician for one 4-hour period for instructions to VA personnel in operation and maintenance of the equipment, on the date requested by the COR.

---END---

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

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01-01-17

VSECTION 26 33 53
STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of the static uninterruptible power supply, indicated in this section as UPS.

1.2 RELATED WORK

- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:
Requirements that apply to all sections of Division 26.
- C. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES:
Low-voltage conductors.
- D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
Requirements for personnel safety and to provide a low impedance path for possible fault currents.
- E. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.
- H. Section 26 26 00, POWER DISTRIBUTION UNITS FOR STATIC UNINTERRUPTIBLE POWER SYSTEMS: Power distribution units connected to the output of a UPS.

1.3 QUALITY ASSURANCE

- A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

- A. UPS shall be thoroughly tested at the factory to assure that there are no electrical or mechanical defects.
- B. Factory Tests shall be in accordance with Paragraph, MANUFACTURED PRODUCTS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:
1. UPS shall be factory full-load tested to meet the requirements specified using a test battery (not the battery to be supplied with the system) with AC input power and with battery power for a minimum of 8 hours, with meter readings taken every 30 minutes. Should a malfunction occur, the problem shall be corrected and the test shall be repeated. The tests shall encompass all aspects of operation,

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

such as module failure, static bypass operation, battery failure,
input power failure and overload ratings.

1.5 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11,
REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following
requirements:

1. Shop Drawings:

- a. Submit sufficient information to demonstrate compliance with drawings and specifications.
- b. Include electrical ratings, dimensions, mounting details, materials, required clearances, terminations, weight, plan, front, side, and rear elevations, accessories, and device nameplate data.
- c. Provide detailed and project-specific system diagram, showing maintenance bypass, UPS module(s), battery cabinet(s) and batteries, major circuit protective devices, interconnecting power and control wiring, key-type mechanical interlocks, and connections to power sources and loads, as applicable. Indicate whether interconnections are factory-provided/factory-installed, factory-provided/field-installed, or field-provided/field installed.

2. Manuals:

- a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering replacement parts.
 - 1) Wiring diagrams shall have their terminals identified to facilitate installation, maintenance, and operation.
 - 2) Wiring diagrams shall indicate internal wiring for each item of equipment and the interconnection between the items of equipment.
 - 3) Provide a clear and concise description of operation, which gives, in detail, the information required to properly operate the UPS, including but not limited to bypass switchboard, UPS, key-type mechanical interlocks, remote devices, emergency

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

power off buttons, fire alarm interface, and other components
as applicable.

- b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
 - 1) Include complete "As Installed" diagrams that indicate all pieces of equipment and their interconnecting wiring.
 - 2) Include complete diagrams of the internal wiring for each piece of equipment, including "As Installed" revisions of the diagrams.
 - 3) The wiring diagrams shall identify the terminals to facilitate installation, maintenance, operation, and testing.
- 3. Test Reports:
 - a. Submit certified factory design and production test reports for approval.
 - b. Two weeks prior to the final inspection, submit certified field test reports and data sheets to the COR.
- 4. Certifications: Two weeks prior to final inspection, submit the following.
 - a. Certification by the manufacturer that the UPS conforms to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that the UPS has been properly installed, adjusted, and tested.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata), form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.
- B. Institute of Engineering and Electronic Engineers (IEEE):
 - C62.41.1-02.....Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits
 - C62.41.2-02.....Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
 - 450-10.....Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

485-10.....Sizing Lead-Acid Batteries for Stationary
Applications

C. International Code Council (ICC):

IBC-15.....International Building Code

D. National Electrical Manufacturers Association (NEMA):

PE 1-12.....Uninterruptible Power Systems - Specification
and Performance Verification

E. National Fire Protection Association (NFPA):

70-17.....National Electrical Code (NEC)

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. System Capacity: Unless stated otherwise, the parameters listed are under full rated output load at a minimum of 0.9 power factor, with batteries fully charged and floating on the DC bus and with nominal input voltage. Overall 80kVA, redundant with MONOLITHIC UPS., at 40 °C.
- B. Battery Capacity: Discharge time to end voltage: 15 minutes, at 25 °C (77 °F). Battery shall be capable of delivering 125 percent of full rated output load at initial start-up.
- C. System Bus Bracing: Braced for amperes symmetrical interrupting capacity as shown on drawings.
- D. AC Input:
1. Voltage 208volts line-to-line.
 2. Number of phases: 3-phase, 3-wire, plus ground.
 3. Voltage Range: Plus 10 percent, minus 15 percent, without affecting battery float voltage or output voltage.
 4. Frequency: 60 Hz, plus or minus 5 percent.
 5. Total harmonic current distortion (THD) reflected into the primary line: 5percent maximum.
- E. AC Output
1. Voltage 208volts line-to-line, 120volts line-to-neutral.
 2. Number of phases: 3-phase, 4-wire, plus ground.
 3. Voltage regulation:
 - a. Balanced load: Plus or minus 1.0 percent.
 - b. 100 percent load imbalance, phase-to-phase: Plus or minus 3 percent.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

4. Frequency: 60 Hz.
5. Frequency regulation: Plus or minus 0.05 percent.
6. Harmonic content (RMS voltage): 5 percent maximum total harmonic distortion with 100% nonlinear load.
7. Load power factor operating range: 1.0 to 0.8 lagging.
8. Phase displacement:
 - a. Balanced load: Plus or minus 1 degree of bypass input.
9. Overload capability (at full voltage) (excluding battery):
 - a. 125 percent load for 10 minutes.
 - b. 150 percent load for 1 minute.
- F. Voltage Transient Response:
 1. 100 percent load step: Plus or minus 5 percent.

2.2 UPS

- A. General Description: UPS module shall consist of a rectifier/charger unit and a 3-phase inverter module unit with their associated transformers, synchronizing equipment, input and output circuit breakers, and accessories as required for operation.
- B. Rectifier/Charger Unit: Rectifier/charger unit shall be solid state and shall provide direct current to the DC bus.
 1. Input Circuit Breaker: Rectifier/charger unit shall be provided with an input circuit breaker. The circuit breaker shall be sized to accept simultaneously the full-rated load and the battery recharge current.
 2. Sizing: Rectifier/charger unit shall be sized for the following two simultaneous operating conditions:
 - a. Supplying the full rated load current to the inverter.
 - b. Recharging a fully-discharged battery to 95 percent of rated ampere-hour capacity within ten times the discharge time after normal AC power is restored, with the input protective device closed.
- C. Inverter Unit: Inverter unit shall be a solid-state device capable of accepting power from the DC bus and providing AC power within specified limits.
 1. Output Overload: The inverter shall be able to sustain an overload as specified across its output terminals.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

2. Synchronism: The inverter shall normally operate in phase-lock and synchronism with the bypass source.
 3. Modular Construction: Each control logic printed circuit board shall be electrically and physically packaged on an individual plug-in module with separate indication and adjustments.
 4. Output Circuit Breaker: The output circuit breaker shall be capable of shunt tripping and shall have interrupting capacity as specified. Circuit breaker shall have provision for locking in the "off" position.
- D. External Protection: UPS module shall have built-in self-protection against undervoltage, overvoltage, overcurrent and surges introduced on the AC input source and/or the bypass source. The UPS system shall sustain input surges without damage in accordance with IEEE C62.41.1 and IEEE C62.41.2. The UPS shall also have built-in self-protection against overvoltage and voltage surges introduced at the output terminals by paralleled sources, load switching, or circuit breaker operation in the critical load distribution system.
- E. Internal Protection: UPS module shall be self-protected against overcurrent, sudden changes in output load and short circuits at the output terminals. UPS module shall be provided with output reverse power detection which shall cause that module to be disconnected from the critical load bus when output reverse power is present. UPS module shall have built-in protection against permanent damage to itself and the connected load for predictable types of failure within itself and the connected load. At the end of battery discharge limit, the module shall shut down without damage to internal components.

2.3 STATIC BYPASS TRANSFER SWITCH

- A. A static bypass transfer switch shall be provided as an integral part of the UPS and shall consist of a static switch and a bypass protective device or bypass switch. The control logic shall contain an automatic transfer circuit that senses the status of the inverter logic signals and alarm conditions and provides an uninterrupted transfer of the load to the bypass AC power source, without exceeding the transient limits specified herein, when a malfunction occurs in the UPS or when an external overload condition occurs.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

1. Static Bypass Transfer Switch Disconnect: A disconnect shall be incorporated to isolate the static bypass transfer switch assembly so it can be removed for servicing. The disconnect shall be equipped with auxiliary contacts and provision for padlocking in either the "on" or "off" position.

2.4 MAINTENANCE BYPASS - SINGLE-MODULE UPS

- A. A maintenance bypass switch shall be provided as an integral part of the UPS and located within the UPS module. The maintenance bypass switch shall provide the capability to continuously support the load from the bypass AC power source while the UPS is isolated for maintenance. The maintenance bypass switch shall be housed in an isolated compartment inside the UPS cabinet. Switch shall contain a maintenance bypass protective device and a module isolation protective device.
- B. The maintenance bypass switch shall provide the capability of transferring the load from the UPS static bypass transfer switch to maintenance bypass and then back to the UPS static bypass transfer switch with no interruption to the load.

2.6 MODULE CONTROL PANEL - SINGLE-MODULE UPS

- A. The UPS module shall be provided with a LCD control/indicator panel. Meters, controls, alarms, system diagnostics, mimic screen showing one-line diagram of the system, and indicators for operation of the UPS shall be on this panel.
 1. Module Meters:
 - a. Meters shall have 1 percent accuracy.
 - b. The following functions shall be monitored and displayed:
 - 1) Input voltage, phase-to-phase (all three phases).
 - 2) Input current, all three phases.
 - 3) Input frequency.
 - 4) Battery voltage.
 - 5) Battery current (charge/discharge).
 - 6) Output voltage, phase-to-phase and phase-to-neutral (all three phases).
 - 7) Output current, all three phases.
 - 8) Output frequency.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

- 9) Output kilowatts.
- 10) Elapsed time meter to indicate hours of operation, 6 digits.
- 11) Bypass voltage, phase-to-phase and phase-to-neutral (all three phases).
- 12) Output kilovars.
- 13) Output kilowatt hours, with 15-minute interval.
- 2. Module Controls:
 - a. Module shall have the following controls:
 - 1) Alarm test/reset function.
 - 2) Module input protective device trip function.
 - 3) Module output protective device trip function.
 - 4) Battery protective device trip function.
 - 5) Emergency Power Off (EPO) pushbutton, with guard.
 - 6) Control power off switch.
 - 7) Static bypass transfer switch enable/disable selector switch.
- 3. Module Alarm Indicators:
 - a. Module shall have indicators for the following alarm items. Any one of these conditions shall turn on an audible alarm and the appropriate summary indicator. Each new alarm shall register without affecting any previous alarm.
 - 1) Input AC power source failure.
 - 2) Input protective device open.
 - 3) Output protective device open.
 - 4) Overload.
 - 5) Overload shutdown.
 - 6) DC overvoltage.
 - 7) DC ground fault.
 - 8) Low battery.
 - 9) Battery discharged.
 - 10) Battery protective device open.
 - 11) Cooling fan failure.
 - 12) Equipment overtemperature.
 - 13) Control power failure.
 - 14) Charger off.
 - 15) Inverter off.
 - 16) Emergency off.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

- 17) UPS on battery.
- 18) Load on static bypass.
- 19) Static bypass transfer switch disabled.
- 20) Inverter output overvoltage, undervoltage, overfrequency, and underfrequency.
- 21) Bypass source overvoltage, undervoltage, overfrequency, and underfrequency.
- 22) Bypass source to inverter out of synchronization.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. The UPS shall be set in place, wired, and connected in accordance with the approved shop drawings and manufacturer's instructions.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. An authorized representative of the UPS manufacturer shall technically supervise and participate during all of the field adjustments and tests. Major adjustments and field tests shall be witnessed by the COR. The manufacturer's representative shall certify in writing that the equipment has been installed, adjusted, and tested in accordance with the manufacturer's recommendations.
- B. Perform manufacturer's required field tests in accordance with the manufacturer's recommendations. In addition, include the following:
 - 1. Visual Inspection and Tests:
 - a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical, electrical, and mechanical condition.
 - c. Verify appropriate anchorage, required area clearances, and correct alignment.
 - d. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energization.
 - e. Verify grounding connections.
 - f. Vacuum-clean enclosure interior. Clean enclosure exterior.
 - g. Verify the correct operation of all alarms and indicating devices.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

- h. Attach a phase rotation meter to the UPS input, output, and bypass buses, and observe proper phase sequences.
 - i. Check and test controls for proper operation.
 - j. Check doors for proper alignment and operation.
 - k. Check and test each protective device for proper mechanical and electrical operation.
2. Load Test: The UPS shall be load tested for a continuous 24 hour period by means of resistive load banks, sized for full rated output load and provided by the UPS manufacturer. The UPS shall be continuously tested at 1/2 load for 8 hours, 3/4 load for 8 hours and full load for 8 hours. If a failure occurs during the burn-in period, the tests shall be repeated. Instrument readings shall be recorded every half hour for the following:
- a. Input voltage and current (all three phases, for each module).
 - b. Input and output frequency.
 - c. Battery voltage for each module.
 - d. Output voltage and current (all three phases, for each module).
 - e. Output kilowatts for each module.
 - f. Output voltage and current (all three phases).
 - g. Output kilowatts.
3. Full Load Burn In Test: The UPS shall undergo an additional full load burn-in period of 24 continuous hours by means of resistive load banks, sized for full rated output load and provided by the UPS manufacturer. If a failure occurs during the burn-in period, the tests shall be repeated. Instrument readings shall be recorded every half hour as above. The following tests shall be performed:
- a. With the UPS carrying full rated output load and supplied from the normal source, switch 100 percentpercent of load bank capacity on and off a minimum of five times within the burn-in period.
 - b. With the UPS carrying maximum continuous design load and supplied from the emergency source, repeat the switching operations described above.
4. Full Load Battery Burn In Test: The UPS shall undergo a full load battery test by means of resistive load banks, sized for full rated output load and provided by the UPS manufacturer. If a failure

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

occurs during the battery discharge time, the tests shall be repeated. Instrument readings shall be recorded every half hour as above.

- a. With the UPS carrying full rated output load and operating on battery power, switch 50 percent of load bank capacity on and off a minimum of five times within the battery discharge time.
5. Battery Discharge and Recharge Test: With the battery fully charged, the UPS shall undergo a complete battery discharge test to full depletion followed by a full recharge. Instrument readings shall be recorded every minute during discharge for the following:
- a. Battery voltage and current
 - b. Output voltage and current (all three phases
 - c. Output kilowatts
 - d. Output voltage and current (all three phases).
 - e. Output kilowatts (system).
 - f. Output frequency.

3.3 FOLLOW-UP VERIFICATION

- A. After completion of acceptance checks and tests, the Contractor shall show by demonstration in service that the UPS is in good operating condition and properly performing the intended function.

3.4 ONE LINE DIAGRAM AND SEQUENCE OF OPERATION

- A. At final inspection, an as-built one line diagram shall be laminated or mounted under acrylic glass, and installed in a frame mounted near the UPS.
- B. Furnish a written sequence of operation for the UPS and connected line side/load side electrical distribution equipment. The sequence of operation shall be laminated or mounted under acrylic glass, and installed in a frame mounted near the UPS.
- C. Deliver an additional four copies of the as-built one line diagram and sequence of operation to the COR.

3.5 INSTRUCTION

- A. Furnish the services of a factory-trained technician for one 4-hour training period for instructing personnel in the maintenance and operation of the UPS, on the dates requested by the COR.

---END---

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

SECTION 26 43 13
SURGE PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Surge Protective Devices shall be specified whenever panel voltage may be detrimental to electronic devices. This section specifies the furnishing, installation, and connection of Type 2 Surge Protective Devices, as defined in NFPA 70, and indicated as SPD in this section.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- C. Section 26 24 13, DISTRIBUTION SWITCHBOARDS: For factory-installed or external SPD.
- D. Section 26 24 16, PANELBOARDS: For factory-installed or external SPD.
- E. Section 26 26 00, POWER DISTRIBUTION UNITS FOR STATIC UNINTERRUPTIBLE POWER SYSTEMS: For factory-installed or external SPD.

1.3 QUALITY ASSURANCE

- A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:
1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Include electrical ratings and device nameplate data.
 2. Manuals:
 - a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering replacement parts.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

- b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
 - a. Certification by the manufacturer that the SPD conforms to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that the SPD has been properly installed.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplement and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.
- B. Institute of Engineering and Electronic Engineers (IEEE):
IEEE C62.41.2-02.....Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.45-08.....Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits
- C. National Fire Protection Association (NFPA):
70-17.....National Electrical Code (NEC)
- D. Underwriters Laboratories, Inc. (UL):
UL 1283-15.....Electromagnetic Interference Filters
UL 1449-14.....Surge Protective Devices

PART 2 - PRODUCTS

2.1 SWITCHBOARD SPD

- A. General Requirements:
 1. Comply with IEEE and UL.
 2. Modular design with field-replaceable modules, or non-modular design.
 3. Fuses, rated at 200 kA interrupting capacity.
 4. Bolted compression lugs for internal wiring.
 5. Integral disconnect switch.
 6. Redundant suppression circuits.
 7. LED indicator lights for power and protection status.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

8. Audible alarm, with silencing switch, to indicate when protection has failed.
9. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status.
Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device.
10. Four-digit transient-event counter.

B. Surge Current per Phase: Minimum 240kA per phase.

2.2 PANELBOARD SPD

A. General Requirements:

1. Comply with UL 1449 and IEEE C62.41.2.
2. Modular design with field-replaceable modules, or non-modular design, installed on outside of panel.
3. Fuses, rated at 200 kA interrupting capacity.
4. Bolted compression lugs for internal wiring.
5. Integral disconnect switch.
6. Redundant suppression circuits.
7. LED indicator lights for power and protection status.
8. Audible alarm, with silencing switch, to indicate when protection has failed.
9. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status.
Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device.
10. Four-digit transient-event counter.

B. Surge Current per Phase: Minimum 120kA per phase.

2.3 ENCLOSURES

A. Enclosures: NEMA 1

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the NEC, as shown on the drawings, and manufacturer's instructions.
- B. Factory-installed SPD: Switchgear, switchboard, or panelboard manufacturer shall install SPD at the factory.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

01-01-17

- C. Field-installed SPD: Contractor shall install SPD with conductors or buses between SPD and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
1. Provide a circuit breaker as a dedicated disconnecting means for TVSS as shown on drawings.
- D. Do not perform insulation resistance tests on switchgear, switchboards, panelboards, or feeders with the SPD connected. Disconnect SPD before conducting insulation resistance tests, and reconnect SPD immediately after insulation resistance tests are complete.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:
1. Visual Inspection and Tests:
- a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical, electrical, and mechanical condition.
 - c. Verify that disconnecting means and feeder size and maximum length to SPD corresponds to approved shop drawings.
 - d. Verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method.
 - e. Vacuum-clean enclosure interior. Clean enclosure exterior.
 - f. Verify the correct operation of all sensing devices, alarms, and indicating devices.

3.3 FOLLOW-UP VERIFICATION

- A. After completion of acceptance checks and tests, the Contractor shall show by demonstration in service that SPD are in good operating condition and properly performing the intended function.

3.4 INSTRUCTION

- A. Provide the services of a factory-trained technician for one 2-hour training period for instructing personnel in the maintenance and operation of the SPD, on the date requested by the COR.

---END---

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 1

Bancroft Architects + Engineers

01-01-18

SECTION 26 51 00
INTERIOR LIGHTING

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. This section specifies the furnishing, installation, and connection of the interior lighting systems. The terms "lighting fixture," "fixture," and "luminaire" are used interchangeably.

1.2 RELATED WORK

- A. Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT: Disposal of lamps.
- B. Section 02 41 00, DEMOLITION: Removal and disposal of lamps and ballasts.
- E. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- F. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.
- G. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.
- H. Section 26 27 26, WIRING DEVICES: Wiring devices used for control of the lighting systems.

1.3 QUALITY ASSURANCE

- A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:
1. Shop Drawings:
- a. Submit the following information for each type of lighting fixture designated on the LIGHTING FIXTURE SCHEDULE, arranged in order of lighting fixture designation.
 - b. Material and construction details, include information on housing and optics system.
 - c. Physical dimensions and description.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 1

Bancroft Architects + Engineers

01-01-18

- d. Wiring schematic and connection diagram.
 - e. Installation details.
 - f. Energy efficiency data.
 - g. Photometric data based on laboratory tests complying with IES Lighting Measurements testing and calculation guides.
 - h. Lamp data including lumen output (initial and mean), color rendition index (CRI), rated life (hours), and color temperature (degrees Kelvin).
 - i. For LED lighting fixtures, submit US DOE LED Lighting Facts label, and IES L70 rated life.
2. Manuals:
- a. Submit, simultaneously with the shop drawings, complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
 - b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
- a. Certification by the Contractor that the interior lighting systems have been properly installed and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. American Society for Testing and Materials (ASTM):
C635/C635M REV A-13.....Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings
- C. Environmental Protection Agency (EPA):
40 CFR 261.....Identification and Listing of Hazardous Waste
- D. Federal Communications Commission (FCC):
CFR Title 47, Part 15...Radio Frequency Devices

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 1

Bancroft Architects + Engineers

01-01-18

CFR Title 47, Part 18...Industrial, Scientific, and Medical Equipment

E. Illuminating Engineering Society of North America (IESNA):

LM-79-08.....Electrical and Photometric Measurements of
Solid-State Lighting Products

LM-80-15.....Measuring Lumen Maintenance of LED Light
Sources

LM-82-12.....Characterization of LED Light Engines and LED
Lamps for Electrical and Photometric Properties
as a Function of Temperature

F. Institute of Electrical and Electronic Engineers (IEEE):

C62.41-91(R1995).....Surge Voltages in Low Voltage AC Power Circuits

G. International Code Council (ICC):

IBC-15.....International Building Code

H. National Electrical Manufacturer's Association (NEMA):

C78.376-14.....Chromaticity of Fluorescent Lamps

SSL 1-16.....Electronic Drivers for LED Devices, Arrays, or
Systems

I. National Fire Protection Association (NFPA):

70-17.....National Electrical Code (NEC)

101-18.....Life Safety Code

J. Underwriters Laboratories, Inc. (UL):

496-17.....Lampholders

924-16.....Emergency Lighting and Power Equipment

1598-08.....Luminaires

2108-15.....Low-Voltage Lighting Systems

8750-15.....Light Emitting Diode (LED) Light Sources for
Use in Lighting Products

PART 2 - PRODUCTS

2.1 LIGHTING FIXTURES

A. Shall be in accordance with NFPA, UL, as shown on drawings, and as specified.

B. Sheet Metal:

1. Shall be formed to prevent warping and sagging. Housing, trim and lens frame shall be true, straight (unless intentionally curved), and parallel to each other as designed.

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 1

Bancroft Architects + Engineers

01-01-18

2. Wireways and fittings shall be free of burrs and sharp edges, and shall accommodate internal and branch circuit wiring without damage to the wiring.
3. When installed, any exposed fixture housing surface, trim frame, door frame, and lens frame shall be free of light leaks.
4. Hinged door frames shall operate smoothly without binding. Latches shall function easily by finger action without the use of tools.
- C. lamps shall be serviceable while the fixture is in its normally installed position.
- D. Lamp Sockets:
 1. Lampholder contacts shall be the biting edge type.
- E. Recessed fixtures mounted in an insulated ceiling shall be listed for use in insulated ceilings.
- F. Mechanical Safety: Lighting fixture closures (lens doors, trim frame, hinged housings, etc.) shall be retained in a secure manner by captive screws, chains, aircraft cable, captive hinges, or fasteners such that they cannot be accidentally dislodged during normal operation or routine maintenance.
- G. Metal Finishes:
 1. The manufacturer shall apply standard finish (unless otherwise specified) over a corrosion-resistant primer, after cleaning to free the metal surfaces of rust, grease, dirt and other deposits. Edges of pre-finished sheet metal exposed during forming, stamping or shearing processes shall be finished in a similar corrosion resistant manner to match the adjacent surface(s). Fixture finish shall be free of stains or evidence of rusting, blistering, or flaking, and shall be applied after fabrication.
 2. Interior light reflecting finishes shall be white with not less than 85 percent reflectances, except where otherwise shown on the drawing.
- H. Lighting fixtures shall have a specific means for grounding metallic wireways and housings to an equipment grounding conductor.
- I. Lighting fixtures in hazardous areas shall be suitable for installation in Class and Division areas as defined in NFPA 70.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 1

Bancroft Architects + Engineers

01-01-18

2.2 BALLASTS (NOT USED)

2.4 EMERGENCY LIGHTING UNIT

- A. Connected to Emergency Power, Complete, self-contained unit with batteries, battery charger, one or more local or remote lamp heads with lamps, under-voltage relay, and test switch.
1. Enclosure: Shall be cast aluminum. Enclosure shall be suitable for the environmental conditions in which installed.
 4. Battery: Shall be maintenance-free nickel-cadmium. Minimum normal life shall be minimum of 10 years.
 5. Battery Charger: Dry-type full-wave rectifier with charging rates to maintain the battery in fully-charged condition during normal operation, and to automatically recharge the battery within 12 hours following a 1-1/2 hour continuous discharge.
 6. Integral Self-Test: Automatically initiates test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing LED.

2.5 LAMPS SHALL BE LED FOR ALL TR ROOM AND DATA CENTER FIXTURES

1. , CRI 80 (minimum), color temperature 3500°K, average rated life equal to or greater than 12,000 hours (based on 3 hour starts), and suitable for use with dimming ballasts, unless otherwise indicated.
2. Lamps shall comply with EPA Toxicity Characteristic Leachate Procedure (TCLP) requirements.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 1

Bancroft Architects + Engineers

01-01-18

2.6 RADIO-INTERFERENCE-FREE FLUORESCENT FIXTURES NOT USED

2.7 WALL MOUNTED FLUORESCENT BEDLIGHT FIXTURES (NOT USED)

2.8 X-RAY FILM ILLUMINATORS (NOT USED)

2.9 LED EXIT LIGHT FIXTURES

A. EXIT LIGHT FIXTURES SHALL MEET APPLICABLE REQUIREMENTS OF NFPA AND UL.

B. HOUSING AND DOOR SHALL BE DIE-CAST ALUMINUM.

C. FOR GENERAL PURPOSE EXIT LIGHT FIXTURES, DOOR FRAME SHALL BE HINGED, WITH LATCH. FOR VANDAL-RESISTANT EXIT LIGHT FIXTURES, DOOR FRAME SHALL BE SECURED WITH TAMPER-RESISTANT SCREWS.

D. FINISH SHALL BE SATIN OR FINE-GRAIN BRUSHED ALUMINUM.

E. THERE SHALL BE NO RADIOACTIVE MATERIAL USED IN THE FIXTURES.

F. FIXTURES:

1. INSCRIPTION PANELS SHALL BE CAST OR STAMPED ALUMINUM A MINIMUM OF 2.25 MM (0.090 INCH) THICK, STENCILED WITH 150 MM (6 INCH) HIGH LETTERS, BAKED WITH RED COLOR STABLE PLASTIC OR FIBERGLASS. LAMPS SHALL BE LUMINOUS LIGHT EMITTING DIODES (LED) MOUNTED IN CENTER OF LETTERS ON RED COLOR STABLE PLASTIC OR FIBERGLASS.

2. DOUBLE-FACED FIXTURES: PROVIDE DOUBLE-FACED FIXTURES WHERE REQUIRED OR AS SHOWN ON DRAWINGS.

3. DIRECTIONAL ARROWS: PROVIDE DIRECTIONAL ARROWS AS PART OF THE INSCRIPTION PANEL WHERE REQUIRED OR AS SHOWN ON DRAWINGS. DIRECTIONAL ARROWS SHALL BE THE "CHEVRON-TYPE" OF SIMILAR SIZE AND WIDTH AS THE LETTERS AND MEET THE REQUIREMENTS OF NFPA 101.

G. VOLTAGE: MULTI-VOLTAGE (120 - 277V).

2.10 LED LIGHT FIXTURES

A. General:

1. LED light fixtures shall be in accordance with IES, NFPA, UL, as shown on the drawings, and as specified.

2. LED light fixtures shall be Reduction of Hazardous Substances (RoHS)-compliant.

3. LED drivers shall include the following features unless otherwise indicated:

a. Minimum efficiency: 85% at full load.

b. Minimum Operating Ambient Temperature: -20° C. (-4° F.)

c. Input Voltage: 120 - 277V (±10%) at 60 Hz.

d. Integral short circuit, open circuit, and overload protection.

e. Power Factor: ≥ 0.95.

f. Total Harmonic Distortion: ≤ 20%.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 1

Bancroft Architects + Engineers

01-01-18

- g. Comply with FCC 47 CFR Part 15.
- 4. LED modules shall include the following features unless otherwise indicated:
 - a. Comply with IES LM-79 and LM-80 requirements.
 - b. Minimum CRI 80 and color temperature 3000° K unless otherwise specified in LIGHTING FIXTURE SCHEDULE.
 - c. Minimum Rated Life: 50,000 hours per IES L70.
 - d. Light output lumens as indicated in the LIGHTING FIXTURE SCHEDULE.
- C. LED Troffers shall be suspended from a ceiling chain.:
 - 1. LED drivers, modules, and reflector shall be accessible, serviceable, and replaceable from below the ceiling.
 - 2. Housing, LED driver, and LED module shall be products of the same manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the NEC, manufacturer's instructions, and as shown on the drawings or specified.
- B. Align, mount, and level the lighting fixtures uniformly.
- C. Wall-mounted fixtures shall be attached to the studs in the walls, or to a 20 gauge metal backing plate that is attached to the studs in the walls. Lighting fixtures shall not be attached directly to gypsum board.
- D. Lighting Fixture Supports:
 - 1. Shall provide support for all of the fixtures. Supports may be anchored to channels of the ceiling construction, to the structural slab or to structural members within a partition, or above a suspended ceiling.
 - 2. Shall maintain the fixture positions after cleaning and relamping.
 - 3. Shall support the lighting fixtures without causing the ceiling or partition to deflect.

Hardware for recessed lighting fixtures:

- a. All fixture mounting devices connecting fixtures to the ceiling system or building structure shall have a capacity for a

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 1

Bancroft Architects + Engineers

01-01-18

horizontal force of 100 percent of the fixture weight and a vertical force of 400 percent of the fixture weight.

- b. Mounting devices shall clamp the fixture to the ceiling system structure (main grid runners or fixture framing cross runners) at four points in such a manner as to resist spreading of these supporting members. Each support point device shall utilize a screw or approved hardware to "lock" the fixture housing to the ceiling system, restraining the fixture from movement in any direction relative to the ceiling. The screw (size No. 10 minimum) or approved hardware shall pass through the ceiling member (T-bar, channel or spline), or it may extend over the inside of the flange of the channel (or spline) that faces away from the fixture, in a manner that prevents any fixture movement.
- c. In addition to the above, the following is required for fixtures exceeding 9 kg (20 pounds) in weight.
 - 1) Where fixtures mounted in ASTM Standard C635 "Intermediate Duty" and "Heavy Duty" ceilings and weigh between 9 kg and 25 kg (20 pounds and 56 pounds), provide two 12 gauge safety hangers hung slack between diagonal corners of the fixture and the building structure.
 - 2) Where fixtures weigh over 25 kg (56 pounds), they shall be independently supported from the building structure by approved hangers. Two-way angular bracing of hangers shall be provided to prevent lateral motion.
- d. Where ceiling cross runners are installed for support of lighting fixtures, they must have a carrying capacity equal to that of the main ceiling runners and be rigidly secured to the main runners.
- E. Furnish and install the new lamps as specified for all lighting fixtures installed under this project, and for all existing lighting fixtures reused under this project.
- F. The electrical and ceiling trades shall coordinate to ascertain that approved lighting fixtures are furnished in the proper sizes and installed with the proper devices (hangers, clips, trim frames, flanges, etc.), to match the ceiling system being installed.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 1

Bancroft Architects + Engineers

01-01-18

- G. Bond lighting fixtures to the grounding system as specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- H. At completion of project, replace all defective components of the lighting fixtures at no cost to the Government.
- I. Dispose of lamps per requirements of Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT, and Section 02 41 00, DEMOLITION.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform the following:

1. Visual Inspection:

- a. Verify proper operation by operating the lighting controls.
- b. Visually inspect for damage to fixtures, lenses, reflectors, diffusers, and louvers. Clean fixtures, lenses, reflectors, diffusers, and louvers that have accumulated dust, dirt, or fingerprints during construction.

2. Electrical tests:

- a. Exercise dimming components of the lighting fixtures over full range of dimming capability by operating the control devices(s) in the presence of the COR. Observe for visually detectable flicker over full dimming range, and replace defective components at no cost to the Government.
- b. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Government. Burn-in period to be 40 hours minimum, unless specifically recommended otherwise by the lamp manufacturer. Replace any lamps which fail during burn-in.

3.3 FOLLOW-UP VERIFICATION

- A. Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that the lighting systems are in good operating condition and properly performing the intended function.

---END---

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

DIVISION 27

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

SECTION 27 05 26
GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies grounding and bonding requirements of communications installations based on the requirements of ANSI/TIA-607-D, Telecommunications Bonding and Grounding (Earthing) for Customer Premises. Work covered by this Section shall consist of furnishing supplies, labor, materials, equipment, labeling, and tools. Testing is required unless otherwise specified. An operable grounding and bonding infrastructure is required as described on the Drawings and/or required by these specifications. All materials shall be listed by a nationally recognized testing laboratory (NRTL).

1.2 SUMMARY

Section Includes:

- A. Required Bonding Busbars.
- B. Supplemental Bonding Networks.
- C. Telecommunications Bonding Conductors.
- D. Joining Requirements.
- E. Overvoltage Surge Protectors.

1.3 REFERENCES

- A. VA Infrastructure Standard for Telecommunications Spaces.
- B. ANSI/TIA-607-D, Telecommunications Bonding and Grounding (Earthing) for Customer Premises.
- C. NFPA 70, National Electrical Code (NEC).
- D. International Annealed Copper Standard (IACS).
- E. BICSI Information Technology Systems Installation Methods Manual (ITSIMM), Recommended Testing Procedures and Criteria.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

F. UL 497 & UL 497A, UL Standards for Primary & Secondary Safety
Protectors for Paired-Conductor Communications Circuits.

1.4 RELATED WORK

- A. Facility grounding and bonding requirements: Section 26 05 26,
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- B. Information Technology equipment enclosures: Section 27 11 16,
COMMUNICATION CABINETS, RACKS, FRAMES, AND ENCLOSURES.
- C. Cable trays: Section 27 05 36, CABLE TRAYS FOR COMMUNICATIONS
SYSTEMS.

1.5 SUBMITTALS

- A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS
FOR COMMUNICATIONS SYSTEMS.
- B. Provide riser diagram indicating location of communications
grounding system connections indicating routing of grounding
conductors.
- C. Closeout Submittals: Provide test reports of ground resistance to
each primary or secondary bonding busbar (PBB/SBB) located in
each telecommunications space impacted by the work.

PART 2 - PRODUCTS

2.1 BONDING BUSBARS.

Bonding busbars are located in each telecommunications space and in
each network rack/cabinet. Bonding busbars provide common locations in
the telecommunications space for the connection of the
telecommunications bonding conductors.

- A. Common Requirements.
 - 1. Provided with holes for use with correctly-matched UL Listed
two-hole lugs and hardware.
 - 2. Constructed of copper or copper alloy with a minimum of 95%
conductivity when annealed.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

3. Annealed as specified by the International Annealed Copper Standard (IACS).
 4. Installation resulting in a maximum 4.0Ω to ground resistance measured from any point in the system.
 5. Installation is insulated from the mounting surface through the use of appropriate insulators.
 6. UL Listed.
- B. Primary Bonding Busbar (PBB). The PBB is a dedicated extension of the building grounding electrode system for the telecommunications infrastructure. The PBB also serves as the central attachment point for Secondary Bonding Busbars (SBB) via Telecommunications Bonding Backbone (TBB).
1. Pre-drilled copper with holes to accommodate lug mounting holes.
 2. Sized for current applications and future growth.
 3. Insulated from its supports.
 4. Electro-tin plated is acceptable.
 5. Maintain a 2" min clearance between busbar and finished wall.
 6. Size must be 0.25" thick by 4" wide by 20" length.
- C. Secondary Bonding Busbar (SBB). The SBB is a common point of connection for telecommunications system and equipment bonding to a ground located in each Telecommunications Room.
1. Pre-drilled holes to accommodate dual-lug mounting holes.
 2. 0.25" thick x 2" wide with varying length to be sized for current applications and future growth.
 3. Maintain a 2" min clearance between the finished wall and busbar.
 4. Copper or tin annealed copper.
- D. Rack Bonding Busbar (RBB). The RBB is a busbar located in a cabinet, rack, or frame.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

1. Mounting. Horizontal mounting to an EIA-310-D 19" equipment rack is specified.
2. Capacity: 10 Double-hole lugs.
3. Size & material 0.75" wide x 19" length x 0.25" thick - Copper or tin annealed copper.

2.2 SUPPLEMENTAL BONDING NETWORKS.

Also known as Signal Reference Grids (SRGs), Mesh Bonding Networks (Mesh-BN), or Isolated Bonding Networks (IBNs), the requirements for supplemental bonding networks are not specified in this document. Supplemental bonding networks may not be used to replace a standards-compliant bonding infrastructure.

2.3 TELECOMMUNICATIONS BONDING BACKBONE (TBB).

The TBB bonds the facility Primary Bonding Busbar (PBB) to telecommunications space Secondary Bonding Busbars (SBBs).

- A. Material. Stranded copper wire with a green jacket (or per NEC depending on size), run as a continuous conductor.
- B. Size. The TBB shall be sized to meet the requirements of ANSI/TIA-607-D and will be as straight as practicable avoiding bends.
- C. Bonding the TBB to the PBB and each SBB will require a UL Listed irreversible compression (crimp) dual-lug connector.

2.4 BONDING CONDUCTORS.

- A. Telecommunications Equipment Bonding Conductor (TEBC). The TEBC connects the cabinets and racks in the telecommunications space to the space's bonding busbar (PBB or SBB).

1. Material. Stranded copper wire with a green jacket (or per NEC depending on size), run as a continuous conductor.
2. Size. The TBB shall be sized to meet the requirements of ANSI/TIA-607-D. The minimum size for the TEBC shall be AWG 6.
3. Bonding. Bonded to the telecommunications space bonding busbar (PBB or SBB) via a UL Listed two-hole compression lug.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

Rack Bonding Conductors (RBCs) are connected to the TEBC using UL Listed irreversible compression (crimp) connectors.

B. Rack Bonding Conductor (RBC). The RBC is a bonding conductor from the cabinet or Rack Bonding Busbar (RBB) to the Telecommunications Equipment Bonding Conductor (TEBC).

1. Material. Stranded copper wire with a green jacket run as a continuous conductor.

2. Size. The minimum size for the RBC shall be AWG 6.

3. Bonding. Bonded to the Telecommunications Equipment Bonding Conductor (TEBC) using UL Listed irreversible compression (crimp) connectors.

a. Where connected to a server cabinet, the RBC extends to the bottom of the server cabinet allowing Equipment Bonding Conductors to be attached at any point in the cabinet.

b. Where connected to a network rack/cabinet, the Rack Bonding Conductor (RBC) is bonded to the Rack Bonding Busbar (RBB) via a UL Listed two-hole compression lug.

C. Equipment/Unit Bonding Conductor (EBC/UBC). The Equipment/Unit Bonding Conductor connects individual equipment in a cabinet or rack to the Rack Bonding Conductor (RBC) or Rack Bonding Busbar (RBB). Equipment Bonding conductors are also used as cable tray bonding conductors to bond cable tray sections to the Telecommunications Equipment Bonding Conductor (TEBC).

1. Material. Stranded copper wire with a green jacket run as a continuous conductor.

2. Size. The minimum size for the RBC shall be AWG 6.

3. Bonding.

a. Where used in a server cabinet, bonded to the Rack Bonding Connector (RBC) using UL Listed irreversible compression (crimp) connectors and to IT equipment via a UL

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

Listed two-hole compression lug. (Some IT equipment may require one-hole lugs.)

b. Where used in a network cabinet/rack, bonded to the Rack Bonding Busbar (RBB) via a UL Listed two-hole compression lug and to IT equipment via a UL Listed two-hole compression lug. (Some IT equipment may require one-hole lugs.)

c. Where used as a cable tray bonding conductor connecting cable tray sections, bonded to each adjoining section of the cable tray using UL Listed two-hole compression lugs.

d. Where used as a cable tray bonding conductor connecting cable tray sections to the Telecommunications Equipment Bonding Conductor (TEBC), bonded to the TEBC using UL Listed irreversible compression (crimp) connectors and to the cable tray via a UL Listed two-hole compression lug.

4. Contractor shall furnish a minimum of ten (10) EBCs for each RBB. Five (5) EBCs shall be outfitted as described here and shall be six (6) feet in length. Five (5) EBCs shall be outfitted as decried here and shall be nine (9) feet in length. Contractor shall use field measurements to determine EBC cable length when directed by VA project managers.

2.5 OVERVOLTAGE SURGE PROTECTORS.

A. Protectors are voltage-limiting devices intended to protect equipment, wiring, and personnel against the effects of excessive potentials and currents in communications lines caused by lightning, contacts with power conductors, power induction, and rises in ground potential.

1. Compliance. Protectors shall be compliant with UL 497 and/or UL 497A, as applicable.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

2. Performance. Protectors shall be rated to support copper UTP performance Category 5e at 100MHz.
3. Protection. Voltage suppression shall be via low capacitance solid state protectors only, rated at 18V for copper backbone applications or 65V for VOIP or PoE applications.
4. Construction. Provide protection for each pair.
5. Termination shall be insulation-displacement contact.
6. Mounting. Protectors shall be rack-mounted.

PART 3 - EXECUTION

3.1 IMPLEMENTATION

- A. Components of the telecommunications bonding system will be installed and connected using materials and techniques required by ANSI/TIA-607-D. The use of antioxidant joint compound is required for all connections excluding protector 110 block connections.
- B. Testing.
 1. Perform tests per BICSI Information Technology Systems Installation Methods Manual (ITSIMM), Recommended Testing Procedures and Criteria.
 2. Perform two-point bond test using trained installers qualified to use test equipment.
 3. Conduct continuity tests to verify that metallic pathways in telecommunications spaces are bonded to PBB or SBB.
 4. Conduct electrical continuity test to verify that PBB is effectively bonded to the facility grounding electrode conductor.
 5. Perform resistance tests to ensure rack and cabinet bonding connection resistance measures less than 4Ω to PBB or SBB.

- - - E N D - - -

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

SECTION 27 05 33
CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies conduit, fittings, and boxes to form raceway systems for communications cabling.

1.2 RELATED WORK

- A. Bedding of conduits: Section 31 20 00, EARTH MOVING.
- B. Sealing around penetrations to maintain integrity of fire rated construction: Section 07 84 00, FIRESTOPPING.
- C. Fabrications for deflection of water away from building envelope at penetrations: Section 07 60 00, FLASHING AND SHEET METAL.
- D. Sealing around conduit penetrations through building envelope to prevent moisture migration into building: Section 07 92 00, JOINT SEALANTS.
- E. Identification and painting of conduit and other devices: Section 09 91 00, PAINTING.
- F. Requirements for personnel safety and to provide a low impedance path for possible ground fault currents: Section 27 05 26, GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS.

1.3 SUBMITTALS

- A. In accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS, submit the following:
 - 1. Size and location of cabinets, splice boxes, and pull boxes.
 - 2. Layout of required conduit penetrations through structural elements.
 - 3. Catalog cuts marked with specific item proposed and area of application identified.
- B. Certification: Provide letter prior to final inspection, certifying material is in accordance with construction documents and properly installed.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

PART 2 - PRODUCTS

2.1 MATERIAL

- A. Minimum Conduit Size: 19 mm (3/4 inch).
- B. Conduit:
 - 1. Rigid Galvanized Steel: Conform to UL 6, ANSI C80.1.
 - 2. Rigid Aluminum: Conform to UL 6A, ANSI C80.5.
 - 3. Rigid Intermediate Steel Conduit (IMC): Conform to UL 1242, ANSI C80.6.
 - 4. Electrical Metallic Tubing (EMT):
 - a. Maximum Size: 105 mm (4 inches).
 - b. Install only for cable rated 600 volts or less.
 - c. Conform to UL 797, ANSI C80.3.
 - 5. Flexible Galvanized Steel Conduit: Conform to UL 1.
 - 6. Liquid-tight Flexible Metal Conduit: Conform to UL 360.
 - 7. Direct Burial Plastic Conduit: Conform to UL 651 and UL 651A, heavy wall PVC, or high density polyethylene (HDPE).
 - 8. Surface Metal Raceway: Conform to UL 5.
- C. Conduit Fittings:
 - 1. Rigid Galvanized Steel and Rigid Intermediate Steel Conduit Fittings:
 - a. Provide fittings meeting requirements of UL 514B and ANSI/NEMA FB 1.
 - b. Sealing: Provide threaded cast iron type. Use continuous drain type sealing fittings to prevent passage of water and vapor. In concealed work, install sealing fittings in flush steel boxes with blank cover plates having same finishes as other electrical plates in room.
 - c. Standard Threaded Couplings, Locknuts, Bushings, and Elbows: Only steel or malleable iron materials are

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

acceptable. Integral retractable type IMC couplings are also acceptable.

- d. Locknuts: Bonding type with sharp edges for digging into metal wall of an enclosure.
 - e. Bushings: Metallic insulating type, consisting of an insulating insert molded or locked into metallic body of fitting. Bushings made entirely of metal or nonmetallic material are not permitted.
 - f. Erickson (union-type) and Set Screw Type Couplings:
 - 1) Couplings listed for use in concrete are permitted for use to complete a conduit run where conduit is installed in concrete.
 - 2) Use set screws of case hardened steel with hex head and cup point to seat in conduit wall for positive ground.
 - g. Provide OEM approved fittings.
2. Rigid Aluminum Conduit Fittings:
- a. Standard Threaded Couplings, Locknuts, Bushings, and Elbows: Malleable iron, steel or aluminum alloy materials; Zinc or cadmium plate iron or steel fittings. Aluminum fittings containing more than 0.4 percent copper are not permitted.
 - b. Locknuts and Bushings: As specified for rigid steel and IMC conduit.
 - c. Set Screw Fittings: Not permitted for use with aluminum conduit.
3. Electrical Metallic Tubing Fittings:
- a. Conform to UL 514B and ANSI/ NEMA FB1; only steel or malleable iron materials are acceptable.
 - b. Couplings and Connectors: Concrete tight and rain tight, with connectors having insulated throats.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

- 1) Use gland and ring compression type couplings and connectors for conduit sizes 50 mm (2 inches) and smaller.
- 2) Use set screw type couplings with four set screws each for conduit sizes over 50 mm (2 inches).
- 3) Use set screws of case-hardened steel with hex head and cup point to seat in wall of conduit for positive grounding.
- c. Indent type connectors or couplings are not permitted.
- d. Die-cast or pressure-cast zinc-alloy fittings or fittings made of "pot metal" are not permitted.
- e. Provide OEM approved fittings.
4. Flexible Steel Conduit Fittings:
 - a. Conform to UL 514B; only steel or malleable iron materials are acceptable.
 - b. Provide clamp type, with insulated throat.
 - c. Provide OEM approved fittings.
5. Liquid-tight Flexible Metal Conduit Fittings:
 - a. Conform to UL 514B and ANSI/ NEMA FB1; only steel or malleable iron materials are acceptable.
 - b. Fittings must incorporate a threaded grounding cone, a steel or plastic compression ring, and a gland for tightening.
 - c. Provide connectors with insulated throats to prevent damage to cable jacket.
 - d. Provide OEM approved fittings.
6. Direct Burial Plastic Conduit Fittings: Provide fittings meeting requirements of UL 514C and NEMA TC3, and as recommended by conduit manufacturer.
7. Expansion and Deflection Couplings:
 - a. Conform to UL 467 and UL 514B.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

- b. Accommodate 19 mm (3/4 inch) deflection, expansion, or contraction in any direction, and allow 30-degree angular deflections.
 - c. Include internal flexible metal braid sized to ensure conduit ground continuity and fault currents in accordance with UL 467, and NEC code tables for ground conductors.
 - d. Jacket: Flexible, corrosion-resistant, watertight, moisture and heat resistant molded rubber material with stainless steel jacket clamps.
8. Rigid Aluminum Fittings:
- a. Provide malleable iron, steel or aluminum alloy materials; zinc or cadmium plate iron or steel fittings. Aluminum fittings containing more than 0.4 percent copper are prohibited.
 - b. Locknuts and Bushings: As specified for rigid steel and IMC conduit.
 - c. Set Screw Fittings: Not permitted for use with aluminum conduit.
 - d. Indent type connectors or couplings are prohibited.
 - e. Die-cast or pressure-cast zinc-alloy fittings or fittings made of "pot metal" are not permitted.
 - f. Provide OEM approved fittings.
- D. Conduit Supports:
- 1. Parts and Hardware: Provide zinc-coat or equivalent corrosion protection.
 - 2. Individual Conduit Hangers: Designed for the purpose, having a pre-assembled closure bolt and nut, and provisions for receiving a hanger rod.
 - 3. Multiple Conduit (Trapeze) Hangers: Minimum 38 mm by 38 mm (1-1/2 by 1-1/2 inch), 2.78 mm (12 gage) steel, cold formed,

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

lipped channels; with minimum 9 mm (3/8 inch) diameter steel hanger rods.

4. Solid Masonry and Concrete Anchors: Self-drilling expansion shields, or machine bolt expansion.

E. Outlet, Splice, and Pull Boxes:

1. Conform to UL-50 and UL-514A.
2. Cast metal where required by NEC or shown, and equipped with rustproof boxes.
3. Sheet Metal Boxes: Galvanized steel, except where otherwise shown.
4. Install flush mounted wall or ceiling boxes with raised covers so that front face of raised cover is flush with wall.
5. Install surface mounted wall or ceiling boxes with surface style flat or raised covers.

F. Warning Tape: Standard, 4-Mil polyethylene 76 mm (3 inch) wide tape detectable type, red with black letters, and imprinted with "CAUTION BURIED COMMUNICATIONS CABLE BELOW".

G. Flexible Nonmetallic Communications Raceway (Innerduct) and Fittings:

1. General: Provide UL 910 listed plenum, riser, and general purpose corrugated pliable communications raceway.
2. Provide Communications Raceway with a factory installed 567 kg (1250 lb.) tensile pre-lubricated pull tape.
3. Use only metallic straps, hangers and fittings to support raceway from building structure. Cable ties are not permitted for securing raceway to building structure.
4. Provide fittings to be installed in spaces used for environmental air made of materials that do not exceed flammability, smoke generation, ignitibility, and toxicity requirements of environmental air space.
5. Size: Metric Designator 53 (trade size 2) or smaller.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

6. Outside Plant: Plenum-rated where each innerduct is 75 mm (3 inches) and larger.
 7. Inside Plant: Listed and marked for installation in plenum airspaces and minimum 25 mm (1 inch) inside diameter.
 8. Plenum: Non-metallic communications raceway.
 - a. Constructed of low smoke emission, flame retardant PVC with corrugated construction.
 - b. UL 94 V-O rating for flame spreading limitation.
 9. Provide innerduct reel lengths as necessary to ensure ducts are continuous.
 10. Provide pulling accessories used for innerduct including but not limited to, inner duct lubricants, spreaders, applicators, grips, swivels, harnesses, and line missiles (blown air) compatible with materials being pulled.
- H. Outlet Boxes:
1. Flush wall mounted minimum 11.9 cm (4-11/16 inches) square, 9.2 cm (3-5/8 inches) deep pressed galvanized steel.
 2. 2-Gang Tile Box:
 - a. Flush backbox type for installation in block walls.
 - b. Minimum 92 mm (3-5/8 inches) deep.
- I. Weatherproof Outlet Boxes: Surface mount two gang, 67 mm (2-5/8 inches) deep weatherproof cast aluminum with powder coated finish internal threads on hubs 19 mm (3/4 inch) minimum.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION AND REQUIREMENTS

A. Penetrations:

1. Cutting or Holes:
 - a. Locate holes in advance of installation. Where proposed in structural sections, obtain approval of structural engineer and COR prior to drilling through structural sections.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

- b. Make holes through concrete and masonry in new and existing structures with a diamond core drill or concrete saw. Pneumatic hammer, impact electric, hand or manual hammer type drills are not permitted; COR may grant limited permission by request, in condition of limited working space.
 - c. Fire Stop: Where conduits, wireways, and other communications raceways pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING.
 - 1) Fill and seal clearances between raceways and openings with fire stop material.
 - 2) Install only retrofittable, non-hardening, and reusable firestop material that can be removed and reinstalled to seal around cables inside conduits.
 - d. Waterproofing at Floor, Exterior Wall, and Roof Conduit Penetrations: Seal clearances around conduit and make watertight as specified in Section 07 92 00, JOINT SEALANTS or directed by waterproofing manufacturer.
- B. Conduit Installation:
- 1. Minimum conduit size of 19 mm (3/4 inch), but not less than size required for 40 percent fill.
 - 2. Install insulated bushings on all conduit ends.
 - 3. Install pull boxes after every 180 degrees of bends (two 90-degree bends) or every 100ft. Size boxes per TIA 569.
 - 4. Extend vertical conduits/sleeves through floors minimum 75 mm (3 inches) above floor and minimum 75 mm (3 inches) below ceiling of floor below.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

5. Terminate conduit runs to and from a backboard in a TR or interstitial space at top or bottom of backboard. Install conduits to enter telecommunication rooms next to wall and flush with backboard.
6. Where drilling is necessary for vertical conduits, locate holes so as not to affect structural sections.
7. Seal empty conduits located in telecommunications rooms or on backboards to prevent entrance of moisture and gases and to meet fire resistance requirements.
8. Provide pull wire in all empty conduits; sleeves through floor are exceptions.
9. Complete each entire conduit run installation before pulling in cables.
10. Flattened, dented, or deformed conduit is not permitted.
11. Ensure conduit installation does not encroach into ceiling height head room, walkways, or doorways.
12. Cut conduit square with a hacksaw, ream, remove burrs, and draw tight.
13. Install conduit mechanically continuous.
14. Independently support conduit at 2.44 m (8 feet) on center; do not use other supports (i.e., suspended ceilings, suspended ceiling supporting members, luminaires, conduits, mechanical piping, or mechanical ducts).
15. Support conduit within 300 mm (1 foot) of changes of direction, and within 300 mm (1 foot) of each enclosure to which connected.
16. Close ends of empty conduit with plugs or caps to prevent entry of debris, until cables are pulled in.
17. Conduit installations under fume and vent hoods are prohibited.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

18. Attach conduits to cabinets, splice cases, pull boxes and outlet boxes with bonding type locknuts. For rigid and IMC conduit installations, provide a locknut on inside of enclosure, made up wrench tight. Do not make conduit connections to box covers.
19. Do not use aluminum conduits in wet locations.
20. Unless otherwise indicated on drawings or specified herein, conceal conduits within finished walls, floors and ceilings.
21. Conduit Bends:
 - a. Make bends with standard conduit bending machines; observe minimum bend radius for cable type and outside diameter.
 - b. Conduit hickey is permitted only for slight offsets, and for straightening stubbed conduits.
 - c. Bending of conduits with a pipe tee or vise is not permitted.
 - d. Minimum radius of communication conduit bends:

Sizes of Conduit Trade Size	Radius of Conduit Bends mm, Inches
3/4	150 (6)
1	230 (9)
1-1/4	350 (14)
1-1/2	430 (17)
2	525 (21)
2-1/2	635 (25)
3	775 (31)
3-1/2	900 (36)
4	1125 (45)

22. Layout and Homeruns - Deviations: Make only where necessary to avoid interferences and only after drawings showing proposed deviations have been submitted and approved by COR.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

C. Concealed Work Installation:

1. In Concrete:

- a. Conduit: Rigid steel or IMC.
- b. Align and run conduit in direct lines.
- c. Install conduit through concrete beams only when the following occurs:
 - 1) Where shown on structural drawings.
 - 2) As accepted by COR prior to construction, and after submittal of drawing showing location, size, and position of each penetration.
- d. Installation of conduit in concrete that is less than 75 mm (3 inches) thick is prohibited.
 - 1) Conduit outside diameter larger than 1/3 of slab thickness is prohibited.
 - 2) Space between Conduits in Slabs: Approximately six conduit diameters apart, except one conduit diameter at conduit crossings.
 - 3) Install conduits approximately in center of slab to ensure a minimum of 19 mm (3/4 inch) of concrete around conduits.
- e. Make couplings and connections watertight. Use thread compounds that are NRTL listed conductive type to ensure low resistance ground continuity through conduits. Tightening set screws with pliers is not permitted.

D. Furred or Suspended Ceilings and in Walls:

1. Rigid steel, IMC or rigid aluminum. Different type conduits mixed indiscriminately in same system is not permitted.
2. Align and run conduit parallel or perpendicular to building lines.
3. Tightening set screws with pliers is not permitted.

E. Exposed Work Installation:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

1. Unless otherwise indicated on drawings, exposed conduit is only permitted in telecommunications rooms.
 - a. Provide rigid steel, IMC or rigid aluminum.
 - b. Different type of conduits mixed indiscriminately in system is not permitted.
 2. Align and run conduit parallel or perpendicular to building lines.
 3. Install horizontal runs close to ceiling or beams and secure with conduit straps.
 4. Support horizontal or vertical runs at not over 2400 mm (96 inches) intervals.
 5. Painting:
 - a. Paint exposed conduit as specified in Section 09 91 00, PAINTING.
 - b. Refer to Section 09 91 00, PAINTING for preparation, paint type, and exact color.
 - c. Provide labels where conduits pass through walls and floors and at maximum 6000 mm (20 foot) intervals in between.
- F. Expansion Joints:
1. Conduits 75 mm (3 inches) and larger, that are secured to building structure on opposite sides of a building expansion joint, require expansion and deflection couplings. Install couplings in accordance with manufacturer's recommendations.
 2. Provide conduits smaller than 75 mm (3 inches) with pull boxes on both sides of expansion joint. Connect conduits to expansion and deflection couplings as specified.
 3. Install expansion and deflection couplings where shown.
- G. Conduit Supports, Installation:
1. Select AC193 code listed mechanical anchors or fastening devices with safe working load not to exceed 1/4 of proof test load.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

2. Use pipe straps or individual conduit hangers for supporting individual conduits. Maximum distance between supports is 2.5 m (8 foot) on center.
3. Support multiple conduit runs with trapeze hangers. Use trapeze hangers designed to support a load equal or greater than sum of the weights of the conduits, wires, hanger itself, and 90 kg (200 pounds). Attach each conduit with U-bolts or other accepted fasteners.
4. Support conduit independent of pull boxes, luminaires, suspended ceiling components, angle supports, duct work, and similar items.
5. Fastenings and Supports in Solid Masonry and Concrete:
 - a. New Construction: Use steel or malleable iron concrete inserts set in place prior to placing concrete.
 - b. Existing Construction:
 - 1) Code AC193 listed wedge type steel expansion anchors minimum 6 mm (1/4 inch) bolt size and minimum 28 mm (1-1/8 inch) embedment.
 - 2) Power set fasteners minimum 6 mm (1/4 inch) diameter with depth of penetration minimum 75 mm (3 inches).
 - 3) Use vibration and shock resistant anchors and fasteners for attaching to concrete ceilings.
6. Fastening to Hollow Masonry: Toggle bolts are permitted.
7. Fastening to Metal Structures: Use machine screw fasteners or other devices designed and accepted for application.
8. Bolts supported only by plaster or gypsum wallboard are not acceptable.
9. Attachment by wood plugs, rawl plug, plastic, lead or soft metal anchors, or wood blocking and bolts supported only by plaster is prohibited.
10. Do not support conduit from chain, wire, or perforated strap.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

11. Spring steel type supports or fasteners are not permitted except horizontal and vertical supports/fasteners within walls.
 12. Vertical Supports:
 - a. Install riser clamps and supports for vertical conduit runs in accordance with NEC.
 - b. Provide supports for cable and wire with fittings that include internal wedges and retaining collars.
- H. Box Installation:
1. Boxes for Concealed Conduits:
 - a. Flush mounted.
 - b. Provide raised covers for boxes to suit wall or ceiling, construction and finish. In spaces not controlled by VA (i.e., common hallways) covers must be lockable.
 2. In addition to boxes shown, install additional boxes where needed to prevent damage to cables during pulling.
 3. Remove only knockouts as required and plug unused openings. Use threaded plugs for cast metal boxes and snap-in metal covers for sheet metal boxes.
 4. Stencil or install phenolic nameplates on covers of boxes identified on riser diagrams; for example "SIG-FA JB No. 1".
 5. Outlet boxes mounted back-to-back in same wall are not permitted. A minimum 600 mm (24 inches) center-to-center lateral spacing must be maintained between boxes.
- I. Flexible Nonmetallic Communications Raceway (Innerduct), Installation:
1. Install Innerduct in cable tray. Innerduct may not be free-hung.
 2. Install only in accessible spaces not subject to physical damage or corrosive influences.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

3. Make bends manually to assure internal diameter of tubing is not effectively reduced.
4. Extend each segment of innerduct minimum 300 mm (12 inches) beyond end of service conduit tie or cable tray. Restrain innerduct ends with wall mount clamps and seal when cable is installed.

3.2 TESTING

- A. Examine fittings and locknuts for secureness.
- B. Test RMC, IMC and EMT systems for electrical continuity and resistance to ground.

- - - E N D - - -

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

SECTION 27 05 36
CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies requirements for telecommunications cabling cable tray and raceway equipment.

1.2 SUMMARY

Section Includes:

- A. Cable Tray.
- B. Fiber Optic Cable Raceway.
- C. Ladder Rack.

1.3 REFERENCES

- A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK:

- A. Grounding and bonding: Section 27 05 26, GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS.

1.5 SUBMITTALS:

- A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS

2.1 CABLE TRAY.

- A. Design. Wire basket with tray insert. Maximum 2" x 4" wire mesh construction. Constructed of round, smooth wire with continuous top side to minimize cable sheath damage.
- B. Finish. Coated to prevent rust.
- C. Size. Cable tray shall be sized to hold the maximum expected cable load at not more than 50% total fill and not more than 6" maximum cable depth. Initial (Day One) fill shall not be over 25% calculated fill capacity.
- D. Accessories. Provide and install the following components and accessories as necessary to achieve the design:
 - 1. Overhead mounting equipment (thread-rod, unistrut, nuts, washers, etc.) suitable for the supporting structural elements.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

2. Tray section splicing hardware.
3. Tray insert.
4. Cable waterfalls.
5. Ground strap kits.
6. Bend radius limiters.

2.2 FIBER OPTIC CABLE RACEWAY.

- A. Design. Raceway system shall be a modular system of channels, fittings, and brackets, able to be assembled with couplers. Fittings for cable spillout shall maintain a minimum 2" bend radius.
- B. Materials. Raceway shall be constructed of rigid PVC and ABS plastics.
- C. Size. Raceway shall be minimum nominally sized 4"x4" or as shown on drawings.
- D. Accessories. Provide and install the following components and accessories as necessary to achieve the design:
 1. Overhead mounting equipment (thread-rod, unistrut, nuts, washers, etc.) suitable for the supporting structural elements.
 2. Channel covers.
 3. Raceway section couplers.
 4. Channel corners and intersections.
 5. Spillway fittings.

2.3 LADDER RACK.

- A. Design. Ladder rack system shall be a modular system of ladder, turns, splices, supports, and accessories able to be assembled with couplers.
- B. Finish. Coated to prevent rust.
- C. Materials. Ladder rack shall be manufactured from tubular steel. Stringers will be 3/8" by 1-1/2" tubular steel. Cross members will be 1" x 1/2". Steel elements shall have a minimum 0.065" wall thickness.
- D. Size. Ladder rack shall be nominally sized 12" width or as called out on drawings.
- E. Accessories. Provide and install the following components and accessories as necessary to achieve the design:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

1. Overhead mounting equipment (thread-rod, unistrut, nuts, washers, etc.) suitable for the supporting structural elements.
2. Ladder rack section couplers (splices).
3. Ladder rack radius bends.
4. Ground strap kits.

PART 3 - EXECUTION

3.1 IMPLEMENTATION:

- A. Cable tray shall be used in horizontal applications. Ladder rack is used in vertical applications.
- B. Cable tray and ladder rack sections shall be bonded together with bonding conductors and the system bonded to the bonding busbar in the space.
- C. Support horizontal cable tray not less than every 5' (shorter spans if recommended by the equipment manufacturer).

- - - E N D - - -

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

SECTION 27 05 53
IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies labeling and identification requirements for information technology (IT) equipment cabinets, racks, and cabling.

1.2 SUMMARY

Section Includes:

- A. Equipment and component labels.
- B. Labeling implementation requirements.

1.3 REFERENCES

- A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK:

- A. Server cabinets and network racks: Section 27 11 16, COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES.
- B. Cable management equipment: Section 27 11 23, COMMUNICATIONS CABLE MANAGEMENT AND LADDER RACK.
- C. Copper UTP cabling: Section 27 13 13, COMMUNICATIONS COPPER BACKBONE CABLING.
- D. Fiber optic cabling: Section 27 13 23, COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING.

1.5 SUBMITTALS:

- A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS

2.1 EQUIPMENT AND COMPONENT LABELS.

- A. Materials. Materials used for labeling equipment, components, and telecommunications cabling shall be appropriate for the installation environment, durable and permanent, and heat-resistant if necessary for labeling in high-temperature environments.

PART 3 - EXECUTION

3.1 IMPLEMENTATION:

- A. Governing Standard. Labeling and identification of equipment, components, and telecommunications cabling shall be based on ANSI/TIA-606-C, Administration Standard for Telecommunications Infrastructure,

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

and NFPA 70, National Electrical Code, as modified by guidance in the
VA Infrastructure Standard for Telecommunications Spaces.

- B. All passive infrastructure equipment, components, and
telecommunications cabling installed shall be labeled at the time of
installation.
- C. Telecommunications cable labeling shall include delivery of complete
and accurate connection documentation (where each cable terminates at
each end) matching the installed labels.
- D. Label locations shall be as specified in the VA Infrastructure Standard
for Telecommunications Spaces.

- - - E N D - - -

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

SECTION 27 10 00
STRUCTURED CABLING

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies requirements for telecommunications structured cabling systems.

1.2 SUMMARY

Section Includes:

- A. Computer Room Backbone Structured Cabling.
- B. Computer Room Horizontal Structured Cabling.
- C. Facility Backbone Structured Cabling.
- D. Facility Horizontal Structured Cabling.

1.3 REFERENCES

- A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK:

- A. Cabling labeling and identification: Section 27 05 53, IDENTIFICATION FOR COMMUNICATIONS SYSTEMS.
- B. Cable termination locations and equipment: Section 27 11 19, COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS.

1.5 SUBMITTALS:

- A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS

2.1 COMPUTER ROOM BACKBONE STRUCTURED CABLING.

Backbone structured cabling in the computer room environment (first level backbone) connects the Main Distribution Areas (MDAs) to the Horizontal Distribution Areas (HDAs).

- A. Install first level backbone structured cabling in overhead cable tray and fiber raceway systems following diverse path routing.
- B. All cabling used shall be pre-terminated and procured to the specific length required by the design (horizontal and vertical paths) with no more than 1 meter of excess length on each end.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

- C. Terminate first level backbone structured cabling in the top RU positions of each network cabinet, working downward, with patch panel equipment mounted on the front rails.
- D. Mirror distribution on the A-side and B-side MDA and HDA elements.
 - 1. In MDA network cabinets:
 - a. Install angled UTP patch panel(s) for each backbone UTP patch panel in the same-side HDA in the computer room beginning in RU45.
 - b. Install an angled panel cover on the lowest UTP patch panel.
 - c. Install a blanking panel in the RU below the UTP patch panels.
 - d. Install fiber optic distribution cabinets to support the backbone fiber distribution from each HDA.
 - e. Install a blanking panel in the RU below the fiber optic distribution cabinet(s).
 - 2. In HDA network cabinets:
 - a. Install fiber optic distribution cabinet(s) and populate with fiber optic distribution cassettes starting in RU45.
 - b. Install a blanking panel in the RU below the last fiber cabinet.
 - c. Install UTP patch panel(s) below the blanking panel.
 - d. Install a blanking panel in the RU below the last UTP patch panel.
- E. Install UTP cables between the same-side MDAs and HDAs.
- F. Install 12- or 24-strand multimode fiber optic cables between each fiber cassette in the HDA to either the same-side MDA or the opposite side MDA as appropriate.

2.2 COMPUTER ROOM HORIZONTAL STRUCTURED CABLING.

Horizontal structured cabling in the computer room environment connects the Equipment Distributors (EDs) in the server cabinets to each supported Horizontal Distribution Area (HDA).

- A. Install horizontal structured cabling in overhead cable tray and fiber raceway systems following diverse path routing.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

- B. All cabling used shall be pre-terminated and procured to the specific length required by the design (horizontal and vertical paths) with no more than 1 meter of excess length on each end.
- C. In the server cabinets, terminate horizontal structured cabling in EDs located in the top 5U of each cabinet, with patch panel equipment mounted on the rear rails.
 - 1. Install fiber optic distribution cabinet(s) starting in RU45 and populate with fiber optic distribution cassettes to support the requirement.
 - 2. Install a blanking panel in the RU below the last fiber cabinet.
 - 3. Install copper UTP patch panel(s) below the blanking panel.
- D. In the HDAs, terminate horizontal structured cabling in the RU positions immediately below the first level backbone structured cabling equipment of each network cabinet, working downward, with patch panel equipment mounted on the front rails.
 - 1. Install fiber optic distribution cabinet(s) and populate with fiber optic distribution cassettes to support each server cabinet.
 - 2. Install a blanking panel in the RU below the fiber optic distribution cabinet(s).
- E. Install 12- or 24-strand multimode fiber optic cables between the server cabinet ED and both HDAs.
- F. Install UTP cables between the server cabinet ED and both HDAs.

2.3 FACILITY BACKBONE STRUCTURED CABLING.

Backbone structured cabling (inter-building and intra-building first level backbone) connects the Entrance Rooms to the Main Distribution Areas (MDAs) in the computer room, and connects the Main Distribution Areas to each Telecommunications Room (TR). This specification describes facility backbone structured cabling when the Entrance Rooms and computer room are in the same building, connected entirely by environmentally conditioned pathways (no outside plant pathways are transited).

- A. Interior to each telecommunications space, install facility backbone structured cabling in overhead cable tray and fiber raceway systems.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

- B. All facility backbone structured cabling shall be redundant and follow diverse path routing.
- C. Facility backbone cabling shall be field-terminated (fusion spliced).
- D. In the Entrance Room, MDA, and TR network cabinets designated for facility backbone distribution, install fiber optic distribution cabinets as required for the quantity of fibers installed.
- E. Between each Entrance Room and the computer room:
 - 1. Provide 2 diversely routed paths of backbone cabling from each Entrance Room. One path will terminate on the A-side MDA and one path will terminate on the B-side MDA.
 - 2. Install a minimum of 24 strands of multimode fiber optic cabling and 12 strands of single-mode fiber optic cabling per path.
 - 3. Populate the fiber optic distribution cabinets on each end with a sufficient quantity of multimode OM4 and single-mode OS1 fiber optic splice cassettes per path.
- F. Between each MDA and each TR:
 - 1. No zone/intermediate distribution areas (ZDAs/IDAs) intermediate cross-connects (ICCs) shall be used. All facility backbone cabling between the MDAs and TRs shall be run directly and continuously.
 - 2. Provide 2 diversely routed paths of backbone cabling, one from the A-side MDA and one from the B-side MDA.
 - 3. Where the TR is located in the same building as the computer room MDAs (does not transit outside plant pathways) and the path distance is less than 400 meters, install a minimum of 24 strands of multimode fiber optic cabling and 12 strands of single-mode fiber optic cabling per path.
 - a. Populate the fiber optic distribution cabinets on each end with a sufficient quantity of multimode OM4 and single-mode OS1 fiber optic splice cassettes per path.
 - 4. Where the TR is located in a different building as the computer room (transits outside plant pathways) or the path distance is greater than 400m, install a minimum of 24 strands of single-mode fiber optic cabling per path.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

- a. Populate the fiber optic distribution cabinets on each end with a sufficient quantity of single-mode OS2 fiber optic splice cassettes per path.

2.4 FACILITY HORIZONTAL STRUCTURED CABLING.

This section not within scope of this project.

PART 3 - EXECUTION

3.1 IMPLEMENTATION:

- A. 100% construction drawing sets shall include drawings detailing the computer room and facility/campus structured cabling systems, including:
 1. Cable media performance categories for each type of run.
 2. Cabling and equipment quantities.
 3. Elevation drawings showing equipment placement in individual enclosures.
 4. Full interconnection diagram for all structured cabling.
 5. Port map and cable label matrices.
- B. All cabling and equipment shall be labeled per the requirements of the VA Infrastructure Standard for Telecommunications Spaces.

- - - E N D - - -

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

SECTION 27 11 16
COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies Information Technology (IT) equipment enclosures for use in VA telecommunications spaces.

1.2 SUMMARY

Section Includes:

- A. Server Cabinets.
- B. Network Cabinets.

1.3 REFERENCES

- A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK:

- A. Cabling termination equipment, rack-mounted: Section 27 11 19, COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS.
- B. Cable management equipment: Section 27 05 36, CABLE TRAYS FOR COMMUNICATIONS SYSTEMS.
- C. Power distribution equipment: Section 27 11 26, COMMUNICATIONS RACK MOUNTED POWER PROTECTION AND POWER STRIPS.
- D. Grounding and bonding equipment: Section 27 05 26, GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS.
- E. Labeling and identification requirements: Section 27 05 53, IDENTIFICATION FOR COMMUNICATIONS SYSTEMS.
- F. Seismic bracing: Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

1.5 SUBMITTALS:

- A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS

2.1 SERVER CABINETS.

- A. Height. Cabinets shall provide 45 standard rack units (RU) of space (45U) for mounting equipment.
- B. Dimensions. Nominal dimensions for server cabinets are 84" (2134mm) tall, 23.6" (600mm) wide, and 48" (1220mm) deep, including side panels and doors. Minimum depth is 46" (1168mm). Maximum width is 24" (610mm).

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

C. Doors and Panels.

1. Front Door. Provide a single locking, latched, hinged metal front door for the server cabinet with minimum 75% open perforated design for airflow.

2. Rear Door. Provide a double locking, latched, hinged metal rear door for the server cabinet.

a. If a vertical exhaust duct (VED, "chimney") is specified for the server cabinet, the rear door shall be solid.

b. If no VED is specified, the rear door shall be perforated with a minimum of 75% open design for airflow.

3. Side Panels. Provide removable, locking solid metal side panels. Side panels shall have cable pass-through cut-outs protected with brushed grommets on each side, aligned on each side to allow Rack PDU cables to pass between enclosures to Zone PDUs.

D. Locks. All locks on a server cabinet shall be keyed the same. Provide two keys per cabinet.

E. Color. The cabinet and all components shall be white in color.

F. Equipment Mounting Rack. The cabinet shall provide an EIA-310-E compliant 19" racking system with front and rear rails using standard 3/8" x 3/8" square hole mounting.

1. Rear Rails. Position rear rails with a minimum of 6" of clearance between the rails and the rear doors to accommodate rear-mounted angled patch panels and up to four (4) vertical rack PDUs.

G. Components. The cabinet shall be supplied with the following standard equipment:

a. Air dams for left and right of the front rails.

b. Finger cable managers.

c. Bottom panel with brushed grommets.

d. Top panel with brushed grommets.

e. Toolless mounting brackets for vertical Rack PDUs.

f. 45U of 1RU blanking panels.

H. Vertical Exhaust Duct. Provide a vertical exhaust duct (VED, or "chimney") matched to the height of the cabinet and facility horizontal return duct.

2.2 NETWORK CHANNEL RACKS.

Not within scope of this project.

2.3 NETWORK CABINETS.

A. Height. Cabinets shall provide 45 standard rack units (RU) of space (45U) for mounting equipment.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

B. Dimensions. Nominal dimensions for server cabinets are 84" (2134mm) tall, 31.5" (800mm) wide, and 48" (1220mm) deep, including side panels and doors. Minimum depth is 46" (1168mm). Maximum width is 24" (610mm).

C. Doors and Panels.

1. Front Door. Provide a single locking, latched, hinged metal front door for the server cabinet with minimum 75% open perforated design for airflow.

2. Rear Door. Provide a double locking, latched, hinged metal rear door for the server cabinet.

a. If a vertical exhaust duct (VED, "chimney") is specified for the server cabinet, the rear door shall be solid.

b. If no VED is specified, the rear door shall be perforated with a minimum of 75% open design for airflow.

3. Side Panels. Provide removable, locking solid metal side panels. Side panels shall have cable pass-through cut-outs protected with brushed grommets on each side, aligned on each side to allow Rack PDU and communications cables to pass between enclosures to Zone PDUs.

D. Locks. All locks on a server cabinet shall be keyed the same. Provide two keys per cabinet.

E. Color. The cabinet and all components shall be white in color.

F. Equipment Mounting Rack. The cabinet shall provide an EIA-310-E compliant 19" racking system with front and rear rails using standard 3/8" x 3/8" square hole mounting.

G. Components. The cabinet shall be supplied with the following standard equipment:

a. Air dams for left and right of the front rails.

b. Bottom panel with brushed grommets.

c. Top panel with brushed grommets.

d. Toolless mounting brackets for vertical Rack PDUs.

e. 45U of 1RU blanking panels.

f. Cable management accessories as necessary to maintain cable bend radii, uniformity, and neatness (e.g. d-rings, spools, bend radius limiters, finger cable managers, waterfalls, etc.).

H. Vertical Exhaust Duct. Provide a vertical exhaust duct (VED, or "chimney") matched to the height of the cabinet and facility horizontal return duct.

2.4 TELECOMMUNICATIONS ENCLOSURES (TE) .

Not within scope of this project.

2.5 PATHWAY RACKS .

Not within scope of this project.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Where to be installed in structures assigned to Seismic Design Category C, D, E, or F, seismic bracing equivalent to that for other storage racks per VA Master Specification 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS section 3.7 ("Install... to withstand earthquake forces and anchored to the floor or laterally braced from the top to the structural elements") is required.
- B. Casters on floor-mounted enclosures shall be retracted and the enclosures leveled and stabilized.

- - - E N D - - -

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

SECTION 27 11 19
COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies cable termination and management equipment to be mounted in information technology (IT) equipment cabinets and racks.

1.2 SUMMARY

Section Includes:

- A. Copper UTP Patch Panels.
- B. Fiber Optic Distribution Cabinets.
- C. Fiber Optic Distribution Cassettes.
- D. Fiber Optic Splice Cassettes.
- E. Horizontal Cable Managers.
- F. Blanking Panels.

1.3 REFERENCES

- A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK:

- A. Server cabinets and network racks: Section 27 11 16, COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES.
- B. Cable management equipment: Section 27 11 23, COMMUNICATIONS CABLE MANAGEMENT AND LADDER RACK.
- C. Labeling and identification requirements: Section 27 05 53, IDENTIFICATION FOR COMMUNICATIONS SYSTEMS.
- D. Copper UTP cabling: Section 27 13 13, COMMUNICATIONS COPPER BACKBONE CABLING.
- E. Copper UTP cabling termination: Section 27 13 13.13, COMMUNICATIONS COPPER CABLE SPLICING AND TERMINATIONS.
- F. Fiber optic cabling: Section 27 13 23, COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING.
- G. Fiber optic cabling termination: Section 27 13 23.13, COMMUNICATIONS OPTICAL FIBER SPLICING AND TERMINATIONS.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

1.5 SUBMITTALS:

- A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS

2.1 COPPER (UTP) PATCH PANELS.

- A. Form Factor. 1U, 19" rack-mountable. Default form factor for patch panels shall be angled to extend not less than 4" (104mm) forward from the mounting rail.
- B. Capacity. 48 copper 8P8C ports in groupings of 6.
- C. Interface. Copper (UTP) patch panels shall accept pre-terminated single 8P8C keystone jacks and 6-jack cassettes.
- D. Accessories. Provide each patch panel installation with the following accessories.
1. Angled panel cover. Specify angled panel covers at the top and bottom of each stack of angled patch panels. Covers shall mount to the same RU rail positions as the top and bottom patch panels.
 2. Rear cable manager tray. Specify one rear cable manager tray per patch panel. Trays shall mount to the same RU rail positions as the patch panel.

2.2 FIBER OPTIC DISTRIBUTION CABINETS.

- A. Form Factor. 1U, 19" rack-mountable, angled to extend not less than 4" (104mm) forward from the mounting rail.
- B. Capacity. 144 fibers in a variety of distribution and/or splice cassettes.
- C. Door. Cabinets shall be supplied with a locking front cover.
- D. Accessories. Provide each distribution cabinet with the following accessories.
1. Rear cable manager. Specify one rear cable manager with fiber storage rings per distribution cabinet. Trays shall mount to the same RU rail positions as the distribution cabinet.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

2. ORU patch cord managers. Specify one pair of patch cord managers per distribution cabinet. Managers shall mount to the same RU rail positions as the distribution cabinet and rear cable manager.

2.3 FIBER OPTIC DISTRIBUTION CASSETTES.

Fiber optic distribution cassettes are used in structured cabling in the computer room to connect Main Distribution Areas (MDAs), Horizontal Distribution Areas (HDAs), and Equipment Distributors (EDs) where pre-terminated cable is used.

- A. Form Factor. Designed to install in rack-mounted fiber optic distribution cabinet.
- B. Connections. The rear connection shall accept 12-strand multi-fiber push-on (MPO) connectors. Adapters on the front of the cassette shall accept 6 duplex Lucent connector (LC) fiber pairs.
- C. Polarity. Provide type universal polarity cassettes.

2.4 FIBER OPTIC SPLICE CASSETTES.

Fiber optic splice cassettes are used in backbone structured cabling connecting the Entrance Rooms to the Main Distribution Areas (MDAs) in the computer room, and the MDAs to Telecommunications Rooms (TRs) where field-terminated (fusion spliced) cable is used.

- A. Form Factor. Designed to install in rack-mounted fiber optic distribution cabinet.
- B. Connections. Adapters on the front of the cassette shall accept 6 duplex Lucent connector (LC) fiber pairs.
- C. Design. Splice cassette modules shall be self-contained to integrate fiber adapter bulkhead and splice holders. No additional splice trays shall be necessary. Each module shall provide 12 fiber splice connections.
- D. Fiber Type. Provide multimode OM4 and single-mode OS2 splice cassettes as required by the quantity of each type of fiber installed.

2.5 HORIZONTAL CABLE MANAGERS.

- A. Form Factor. 1U, 19" rack-mountable.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

B. Door. Horizontal cable managers shall have a double-hinged front cover to protect installed cables.

C. Fingers. 6-port spacing (five fingers).

2.6 BLANKING PANELS.

A. Horizontal Blanking Panels

1. Form Factor. 1U, 19" rack-mountable, angled to extend 4" (104mm) forward from the mounting rail.

2. Transition. Blanking panel shall have a transition cover from angled front to flat front.

3. Quantity. Provide blanking panels to fill 75% of all RUs in all server cabinets and network cabinets.

4. Color: White to match cabinets.

B. Vertical Blanking Panels

1. Form Factor: Matched to height of cabinets, equipped with leveling legs.

2. Shall be sized to cover space between cabinets due to building expansion joint.

3. Panel shall be specifically designed to expand and contract as required due to building expansion joint while maintaining air flow continuity within cold aisle as noted on drawings.

4. Color: White to match cabinets.

PART 3 - EXECUTION

3.1 INSTALLATION:

Not used.

- - - E N D - - -

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

SECTION 27 11 26
COMMUNICATIONS RACK MOUNTED POWER PROTECTION AND POWER STRIPS

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies power distribution equipment and interconnections supporting equipment deployed in telecommunications spaces (entrance rooms, computer rooms, and telecommunications rooms).

1.2 SUMMARY

Section Includes:

- A. Zone Power Distribution Units (zPDUs).
- B. Rack Power Distribution Units (rPDUs).

1.3 REFERENCES

- A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK

- A. General electrical requirements that are common to more than one section in Division 27: Section 27 05 11, REQUIREMENTS FOR COMMUNICATIONS INSTALLATIONS.
- B. IT equipment enclosures: Section 27 11 16, COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES

1.5 SUBMITTALS

- A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.
- B. For each type of product:
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for rack-mounted power protection and power strips.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

PART 2 - PRODUCTS

2.1 ZONE POWER DISTRIBUTION UNITS (ZONE PDU)

- A. Provide components from a single manufacturer.
- B. 60 Amp Zone PDU:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

1. Description: Zone PDU with A/B redundant 3-phase 60A input circuits and three (3) pairs of A/B redundant L21-20R outlets allowing each supported Standard Density (5kW) enclosure to operate at full density rating.
2. Input Connection: Dual 60A three-phase 208V hard-wired, with junction box and five-wire (L+L+L+N+G) DIN copper terminal blocks accommodating 4AWG conductors. Power cord 10' (3m) length.
3. Output Connection: Three (3) pairs of A/B (redundant) L21-20R outlets.
4. Power Capacity: 43.2kW (21.6kW redundant at full load); 5.7kW fully-rated at each L21-20R outlet.
5. Enclosure: Fully self-contained.
6. Mounting: 1" rack-mount.

C. 30 Amp Zone PDU:

1. Description: Zone PDU with A/B redundant 3-phase 30A input circuits and two (2) pairs of A/B redundant L21-20R outlets allowing each supported Standard Density (5kW) enclosure to operate at partial density rating.
2. Input Connection: Dual 30A three-phase 208V L21-30P. Power cord 10' (3m) length.
3. Output Connection: Two (2) pairs of A/B (redundant) L21-20P outlets.
4. Power Capacity: 21.6kW (10.8kW redundant at full load); combined 8.6kW rated output through each A/B pair of L21-20R outlets.
5. Enclosure: Fully self-contained.
6. Mounting: 1" rack-mount.

2.2 RACK POWER DISTRIBUTION UNITS (RACK PDUS)

- A. Provide components from a single manufacturer.
- B. Description: Metered/monitored three-phase 208V 20A vertical Rack Power Distribution Unit (Rack PDU), 5.7kW, with IEC60320 outlets.
- C. Input Connection: Single input NEMA L21-20P plug (twistlock three-phase five wire L+L+L+N+G). Power cord 10' (3m) length.
- D. Output Connections.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

1. For Computer Room applications: Minimum 30 each C13 and 6 each C19. Outlets grouped in phase-grouping banks (A-B, B-C, C-A) or alternating to assist with phase balancing. Outlets labelled with associated phase-grouping bank.
 2. For Telecommunications Room (TR) and entrance room applications: Minimum 30 each C13, 6 each C19, 2 each L5-20. Outlets grouped in phase-grouping banks (A-B, B-C, C-A) or alternating to assist with phase balancing. Outlets labelled with associated phase-grouping bank.
- E. Power Capacity: 5.7kW rated.
- F. Enclosure: Fully self-contained.
- G. Mounting: Toolless mounting, orientation vertical at rear of enclosure, taking up zero RU spaces. Up to two Rack PDUs must be able to be installed on each side for High Density (10kW) enclosures.
- H. Mounting Hardware: As required to connect to the specific enclosure make/model.
- I. Number of RPDUs: 2 for Standard Density (up to 5kW) enclosures, 4 for High Density (10kW) enclosures.
- J. Metering: Local display provides input line currents (Amperage). Additional metering items (voltage, power, energy, power factor) across the unit or at individual outlets, is acceptable.
- K. Monitoring: RJ45 Ethernet port allows connection to an external monitoring system. Supports SNMP v3 with SSL Encryption.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. DEFINITION: Sides (left/right) of the enclosure are as when viewed from the rear (hot aisle) of the enclosure for the purposes of this section.
- B. Zone PDUs.
1. Install Zone PDUs only in enclosures that require them.
 2. Zone PDUs shall not be installed in enclosures supported by busbar power distribution.
 3. Install Zone PDUs beginning in RU position 1 or the first open RU position above any rack-mounted UPS unit, at the bottom of

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

the 19" rack, on the rear rails of the enclosure.

4. Connect the Zone PDU power cords to the upstream branch circuit supporting the enclosures.

C. Rack PDUs.

1. Install Rack PDUs in matched A/B pairs only.
2. Install A side Rack PDUs on the left side of the enclosure and B side Rack PDUs on the right side of the enclosure, interior to the rear enclosure door.
3. Connect the Rack PDU power cord to the upstream rack-mounted UPS unit (where present) or the appropriate power receptacle on the upstream Zone PDU.

- - - E N D - - -

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

SECTION 27 13 13.13
COMMUNICATIONS COPPER CABLE SPLICING AND TERMINATIONS

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies requirements for terminations of copper (UTP) cabling.

1.2 SUMMARY

Section Includes:

- A. Termination Requirements.
- B. Splicing.

1.3 REFERENCES

- A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK:

- A. Termination equipment: Section 27 11 19, COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS.
- B. Copper (UTP) cabling requirements: Section 27 13 13, COMMUNICATIONS COPPER BACKBONE CABLING.
- C. Copper (UTP) cabling requirements: Section 27 15 13, COMMUNICATIONS COPPER HORIZONTAL CABLING.

1.5 SUBMITTALS:

- A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 TERMINATION REQUIREMENTS.

- A. Terminate copper (UTP) cabling used for data communications per TIA 568B.
- B. Connections shall be made to equipment certified to performance category 6a.
- C. Pre-terminated connections are preferred for computer room structured cabling applications. Field termination for non-computer room applications is acceptable.

3.2 SPLICING.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

Splicing of copper (UTP) cabling is prohibited.

- - - E N D - - -

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

SECTION 27 13 13
COMMUNICATIONS COPPER BACKBONE CABLING

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies requirements for telecommunications copper (UTP) backbone and horizontal cabling in structured cabling systems in computer rooms.

1.2 SUMMARY

Section Includes:

- A. Copper (UTP) Backbone Cables.

1.3 REFERENCES

- A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK:

- A. Computer room structured cabling: Section 27 10 00, STRUCTURED CABLING.
- B. Termination equipment: Section 27 11 19, COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS.
- B. Cable labeling requirements: Section 27 05 53, IDENTIFICATION FOR COMMUNICATIONS SYSTEMS.

1.5 SUBMITTALS:

- A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS

2.1 COPPER (UTP) BACKBONE CABLES.

Copper (UTP) backbone and horizontal cables are used in computer room structured cabling to connect Main Distribution Areas (MDAs), Horizontal Distribution Areas (HDAs), and server cabinet Equipment Distributors (EDs).

- A. Performance Category. Copper (UTP) backbone cables shall meet the Category 6A performance requirements. Category 6A connectors are required.
- B. Performance Specifications. Meets or exceeds TIA-EIA-568-C.2-10 and TSB-155.
- C. Limited Power (LP) Certification. UL Listed as x-LP (0.5A).
- D. Termination. Factory pre-terminated TIA 568B.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

E. Testing. Factory certified to meet performance category requirements per TIA 568-C.2.

F. Conductor Size. 22-24AWG.

G. Jacket Rating. Communications Multipurpose Cable, Plenum (CMP) shall be specified if any portion of the cable passes through an NEC-defined plenum. Communications Multipurpose Cable, Riser (CMR) shall be specified for all other applications. CMP may be used as a substitute for CMR.

H. Bundling and Construction. Copper (UTP) backbone cables shall be provided in 6-cable bundles with individual 8P8C media interface connectors (RJ-45 'jacks') or 6-jack cassettes designed to fit in copper (UTP) patch panels.

I. Color. A-side 8P8C media interface connectors (RJ-45) shall be blue. B-side 8P8C connectors shall be yellow.

J. Length. Backbone cabling used shall be procured to the specific length required by the design (horizontal and vertical paths) with no more than 2 feet of excess length.

PART 3 - EXECUTION

3.1 IMPLEMENTATION.

A. A. All cabling and equipment shall be labeled per the requirements of the VA Infrastructure Standard for Telecommunications Spaces.

B. Install first level backbone and horizontal structured cabling in the computer room in cable tray and fiber raceway systems following diverse path routing.

- - - E N D - - -

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

SECTION 27 13 23.13
COMMUNICATIONS OPTICAL FIBER SPLICING AND TERMINATIONS

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies requirements for terminations of fiber optic cabling.

1.2 SUMMARY

Section Includes:

A. Termination Requirements.

1.3 REFERENCES

A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK:

A. Termination equipment: Section 27 11 19, COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS.

B. Fiber optic cabling requirements: Section 27 13 23, COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING.

1.5 SUBMITTALS:

A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 TERMINATION REQUIREMENTS.

A. Terminate fiber optic cabling with 12-fiber multi-fiber push on (MPO) connectors as required for the application.

B. Pre-terminated connections are preferred for computer room structured cabling applications. Field termination (fusion splicing) for non-computer room applications where cable lengths cannot be determined in advance is acceptable.

- - - E N D - - -

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

SECTION 27 13 23
COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies requirements for telecommunications optical fiber backbone cabling.

1.2 SUMMARY

Section Includes:

- A. Multimode Optical Fiber Backbone Cables.
- B. Single Mode Optical Fiber Backbone Cables.

1.3 REFERENCES

- A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK:

- A. Computer room structured cabling: Section 27 10 00, STRUCTURED CABLING.
- B. Termination equipment: Section 27 11 19, COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS.
- B. Cable labeling requirements: Section 27 05 53, IDENTIFICATION FOR COMMUNICATIONS SYSTEMS.

1.5 SUBMITTALS:

- A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS

2.1 MULTIMODE OPTICAL FIBER BACKBONE CABLES.

Multimode fiber optic backbone cables are specified for inside plant use, for data center backbone use as well as for intrabuilding campus backbone.

- A. Performance Category. Laser-optimized OM4 or OM5 cables are specified.
- B. Testing. All fiber optic backbone media shall pass all Tier 1 requirements (attenuation with an Optical Loss Test Set or OLTS, verification of cable length and polarity) and all Tier 2 requirements (characterization by an Optical Time Domain Reflectometer or OTDR resulting in indication of the uniformity of cable attenuation and connector insertion loss).

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

C. Termination. For computer room first level backbone usage, factory pre-terminated cables with MPO connectors are required. Fiber will be field terminated (fusion spliced) when used to connect the computer room to Telecommunications Rooms (TRs) and other telecommunications spaces.

1. Polarity. For pre-terminated MPO-MPO cables, the polarity of the cables shall be matched to the type of fiber optic distribution cassettes specified.

D. Jacket Color.

1. OM4. Aqua.
2. OM5. Lime.

E. Jacket Rating. Communications Multipurpose Cable, Plenum (CMP) shall be specified if any portion of the cable passes through an NEC-defined plenum. Communications Multipurpose Cable, Riser (CMR) shall be specified for all other applications. CMP may be used as a substitute for CMR.

F. Bundling and Construction. Bundles consisting of multiples of sub-bundles (subunits) of 12 strands of fiber are specified. Cables shall be dielectric and tight-buffered. Construction shall match the rear entry requirements of the fiber optic distribution or splice cassette such that the sub-bundle (subunit) remains jacketed into the cassette.

G. Length. Backbone cabling for computer room first level backbone use (pre-terminated) shall be procured to the specific length required by the design (horizontal and vertical paths) with no more than 1 meter of excess length on each end.

2.2 SINGLE MODE OPTICAL FIBER BACKBONE CABLES.

Single mode fiber optic backbone cables are specified for inside and outside plant use, for campus backbone (interbuilding and intrabuilding) use.

A. Performance Category. OS1 is specified for inside plant applications. Inside/outside rated OS2 is specified for applications where the pathway transits an outside plant path.

B. Testing. All fiber optic backbone media shall pass all Tier 1 requirements (attenuation with an Optical Loss Test Set or OLTS,

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

verification of cable length and polarity) and all Tier 2 requirements (characterization by an Optical Time Domain Reflectometer or OTDR resulting in indication of the uniformity of cable attenuation and connector insertion loss).

C. Termination. Fiber will be field terminated (fusion spliced) when used to connect the computer room to Telecommunications Rooms (TRs) and other telecommunications spaces.

D. Jacket Color. Yellow.

E. Jacket Rating. Communications Multipurpose Cable, Plenum (CMP) shall be specified if any portion of the cable passes through an NEC-defined plenum. Communications Multipurpose Cable, Riser (CMR) shall be specified for all other applications. CMP may be used as a substitute for CMR.

F. Bundling and Construction. Bundles consisting of multiples of sub-bundles (subunits) of 12 strands of fiber are specified. Cables shall be dielectric and tight-buffered for OS1, and loose-tube gel-filled for OS2.

PART 3 - EXECUTION

3.1 IMPLEMENTATION.

- A. A. All cabling and equipment shall be labeled per the requirements of the VA Infrastructure Standard for Telecommunications Spaces.
- B. Interior to telecommunications spaces, install fiber optic backbone cabling in overhead cable tray and fiber raceway systems.

- - - E N D - - -

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

SECTION 27 15 13
COMMUNICATIONS COPPER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies requirements for telecommunications copper (UTP) horizontal distribution cabling outside of the computer room. For copper (UTP) horizontal cabling in structured cabling systems in the computer room, see Section 27 13 13 Communications Copper Backbone Cabling.

1.2 SUMMARY

Section Includes:

A. Copper (UTP) Horizontal Cables.

1.3 REFERENCES

A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK:

A. Computer room structured cabling: Section 27 10 00, STRUCTURED CABLING.

B. Termination equipment: Section 27 11 19, COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS.

B. Cable labeling requirements: Section 27 05 53, IDENTIFICATION FOR COMMUNICATIONS SYSTEMS.

1.5 SUBMITTALS:

A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS

2.1 COPPER (UTP) HORIZONTAL CABLES.

Copper (UTP) horizontal cables connect the Telecommunications Room (TR) to each end-user Work Area Outlet (WAO) (horizontal distribution).

A. Performance Category. Copper (UTP) horizontal cables shall meet the Category 6A performance requirements. Category 6A connectors are required.

B. Performance Specifications. Meets or exceeds TIA-EIA-568-C.2-10 and TSB-155.

C. Limited Power (LP) Certification. UL Listed as x-LP (0.5A).

D. Termination. Field terminated TIA 568B.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

E. Testing. Following installation, each cable shall be field certified to meet performance category requirements per TIA 568-C.2.

F. Conductor Size. 22-24AWG.

G. Jacket Rating. Communications Multipurpose Cable, Plenum (CMP) shall be specified if any portion of the cable passes through an NEC-defined plenum. Communications Multipurpose Cable, Riser (CMR) shall be specified for all other applications. CMP may be used as a substitute for CMR.

H. Construction. Copper Clad Aluminum (CCA) cable is not permitted.

J. Length. The maximum distance for UTP horizontal cables is limited to 295 feet.

PART 3 - EXECUTION

3.1 IMPLEMENTATION.

A. A. All cabling and equipment shall be labeled per the requirements of the VA Infrastructure Standard for Telecommunications Spaces.

B. Interior to the TR, install horizontal copper (UTP) structured cabling in overhead cable tray.

- - - E N D - - -

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

SECTION 27 16 19
COMMUNICATIONS PATCH CORDS, STATION CORDS, AND CROSS CONNECT WIRE

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies requirements for telecommunications patch cords.

1.2 SUMMARY

Section Includes:

- A. Copper (UTP) Patch Cables.
- B. Fiber Optic Patch Cables.

1.3 REFERENCES

- A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK:

- A. Termination equipment: Section 27 11 19, COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS.
- B. Cable labeling requirements: Section 27 05 53, IDENTIFICATION FOR COMMUNICATIONS SYSTEMS.

1.5 SUBMITTALS:

- A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS

2.1 COPPER (UTP) PATCH CABLES.

- A. Performance Category. Patch cables shall meet the Category 6A performance requirements. Category 6A connectors are required.
- B. Termination Method. Factory pre-terminated TIA 568B.
- C. Conductor Size. 22-28AWG. Where 28AWG patch cords are specified, the overall horizontal channel distance is reduced.
- D. Length. Patch cords of the shortest appropriate length shall be used.

2.2 FIBER OPTIC PATCH CABLES.

- A. Construction. Fiber patch cords shall be constructed of pairs (2-strands) of either multimode laser-enhanced 50/125µm or single mode laser-optimized 9/125µm fiber. Match fiber optic patch cables to fiber optic backbone cabling installed to the cassette.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

12-01-22

B. Performance Category. Multimode patch cords shall meet the OM4 performance requirements.

C. Performance Category. Single mode patch cords shall meet the OS1 / OS2 performance requirements.

D. Connectors. Duplex Lucent connector (LC) connectors are required. Where polarity requirements are not known, reversible polarity duplex LC connectors are specified on one end.

E. Termination Method. Factory pre-terminated.

F. Length. Patch cords of the shortest appropriate length shall be used.

PART 3 - EXECUTION

3.1 IMPLEMENTATION.

A. Patch cords shall not be used to connect equipment in different server cabinets.

B. Patch cords shall be neatly installed using cable management equipment and following cable management principles.

C. Upon installation patch cords shall be labeled in accordance with the requirements of the VA Infrastructure Standard for Telecommunications Spaces.

- - - E N D - - -

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-28-23

SECTION 27 78 00
CLOSEOUT SUBMITTALS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

This section includes submittal requirements for communications installations and applies to all sections of Division 27. This section is intended to supplement 27 05 00 Common Work Results for Communications until such time as that section can be coordinated and republished.

1.2 REFERENCES

- A. VA Infrastructure Standard for Telecommunications Spaces.

1.3 RELATED WORK

The requirements of this specification shall apply to all sections of Division 27.

- A. General requirements: Section 01 00 00, GENERAL REQUIREMENTS.
- B. Submittal requirements: Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Assign a single communications project manager to serve as point of contact for Government, contractor, and design professional.
- B. Contact the project Contracting Officer's Representative (COR) to have reviewers from the VA Office of Information Technology (OIT) Data Center & Infrastructure Engineering team assigned to review project submittals and designs.

1.5 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Government preapproval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office(s) that will review the submittal for the Government.
- C. Submittal Drawings (G): All drawings shall utilize current equipment and telecommunications space nomenclature. G: Data Center & Infrastructure Operations (DCIE), local site Facility Management

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-28-23

Service (FMS), local site Office of Information Technology (OIT), Healthcare Environment and Facilities Program (HEFP), others as necessary.

1. Telecommunications Space Plans/Elevations: Provide enlarged floor plans of telecommunication spaces indicating layout of equipment and devices, including electrical receptacles and grounding provisions. Submit detailed plan views and elevations of telecommunication spaces showing enclosures, termination equipment, supporting electrical and mechanical infrastructure equipment, and cable paths. Include following rooms:
 - a. Telecommunications Rooms (TRs) and Antenna Entrance Rooms.
 - b. Telecommunication Entrance Rooms.
 - c. Computer Room.
 2. Cable Plant Distribution Plans: Provide facility and campus plan drawings showing inside plant and outside plant diverse path distribution pathways, distances, media types, and equipment.
 3. Computer Room Structured Cabling Plans: Provide logical, schematic, and plan drawings of the structured cabling system in the facility computer room showing diverse path distribution pathways, distances, media types, and equipment.
 4. Logical Drawings: Provide logical riser or schematic drawings for cable plant and grounding/bonding systems. Show termination points and identify wiring connections.
 5. IT Equipment Enclosure Elevation Drawings: Provide elevation drawings of racks and cabinets in all telecommunications spaces showing passive equipment layouts, grounding and bonding details, and power distribution equipment details.
- D. Submittal Components (G): Provide manufacturer's cut sheets or similar for each element below showing conformance with Division 27 and VA [Infrastructure Standard for Telecommunications Spaces](#) salient characteristics and requirements. G: Data Center & Infrastructure Operations (DCIE), local site Facility Management Service (FMS), local site Office of Information Technology (OIT), Healthcare Environment and Facilities Program (HEFP), others as necessary.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-28-23

1. Bonding Busbars (Primary, Secondary, Rack)
2. Overvoltage Surge Protectors
3. Wire Basket Cable Tray and Accessories
4. Server Cabinets and Accessories
5. Network Channel Racks or Network Cabinets and Accessories
6. Telecommunications Enclosures and Accessories
7. Copper UTP Patch Panels and Accessories
8. Fiber Distribution Panels and Accessories
9. Horizontal Cable Managers
10. Blanking Panels
11. Zone Power Distribution Units (zPDUs)
12. Rack Power Distribution Units (rPDUs)
13. Rack-Mounted Uninterruptible Power Supply (UPS) Units
14. Temperature/Humidity Sensors
15. Copper UTP Backbone (Trunk) Cables
16. Multimode Optical Fiber Backbone Cables (data center backbone)
17. Single Mode Optical Fiber Backbone Cable Media (campus backbone)
18. Hybrid MM/SM Optical Fiver Backbone Cable Media (campus backbone)
19. Copper UTP Horizontal Cable Media
20. Copper UTP Patch Cords
21. Fiber Optic Patch Cords

E. Provide parts list including quantity of spare parts.

F. Provide manufacturer product information. Government reserves the right to require a list of installations where products have been in operation.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-28-23

- G. Submittals are required for all equipment anchors and supports, including seismic support design.
- H. Furnish electronic certified test reports to COR prior to final inspection and not more than 90 days after completion of tests.

1.6 CLOSEOUT SUBMITTALS

- A. Provide following closeout submittals prior to project closeout date:
 - 1. Warranty certificate.
 - 2. Evidence of compliance with requirements such as low voltage certificate of inspection.
 - 3. Project record documents.
 - 4. Instruction manuals and software that are a part of system.
- B. Maintenance and Operation Manuals: Submit in accordance with Section 01 00 00, GENERAL REQUIREMENTS.
 - 1. Prepare a manual for each system and equipment specified.
 - 2. Furnish on portable storage drive in PDF format or equivalent accepted by COR.
 - 3. Furnish complete manual as specified in specification section, fifteen days prior to performance of systems or equipment test.
 - 4. Furnish remaining manuals prior to final completion.
 - 5. Identify storage drive "MAINTENANCE AND OPERATION MANUAL" and system name.
 - 6. Include name, contact information and emergency service numbers of each subcontractor installing system or equipment and local representatives for system or equipment.
 - 7. Provide a Table of Contents and assemble files to conform to Table of Contents.
 - 8. Operation and Maintenance Data includes (as appropriate for each item):
 - a. Approved shop drawing for each item of equipment.
 - b. Internal and interconnecting wiring and control diagrams with data to explain detailed operation and control of equipment.
 - c. A control sequence describing start-up, operation, and shutdown.
 - d. Description of function of each principal item of equipment.
 - e. Installation and maintenance instructions.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-28-23

- f. Safety precautions.
- g. Diagrams and illustrations.
- h. Test Results and testing methods.
- i. Performance data.
- j. Pictorial "exploded" parts list with part numbers. Emphasis to be placed on use of special tools and instruments. Indicate sources of supply, recommended spare parts, and name of servicing organization.
- k. Warranty documentation indicating end date and equipment protected under warranty.
- l. Appendix: List qualified permanent servicing organizations for support of equipment, including addresses and certified personnel qualifications.

1.7 QUALITY ASSURANCE

- A. System Supplier Qualifications: System supplier must be authorized by OEM to warranty installed equipment.
- B. Manufactured Products:
 - 1. Comply with FAR clause 52.236-5 for material and workmanship.
 - 2. When more than one unit of same class of equipment is required, units must be product of a single manufacturer.
 - 3. Equipment Assemblies and Components:
 - a. Components of an assembled unit need not be products of same manufacturer.
 - b. Manufacturers of equipment assemblies, which include components made by others, to assume complete responsibility for final assembled unit.
 - c. Provide compatible components for assembly and intended service.
 - d. Constituent parts which are similar must be product of a single manufacturer.
 - 4. Identify factory wiring on equipment being furnished and on wiring diagrams.
- C. Testing Agencies: Government reserves the option of witnessing factory tests. Notify COR minimum 15 working days prior to manufacturer performing the factory tests.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-28-23

1. When equipment fails to meet factory test and re-inspection is required, contractor is liable for additional expenses, including expenses of Government.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements:

1. Government's approval of submittals must be obtained for equipment and material before delivery to job site.
2. Deliver and store materials to job site in OEM's original unopened containers, clearly labeled with OEM's name and equipment catalog numbers, model and serial identification numbers for COR to inventory equipment.

B. Storage and Handling Requirements:

1. Equipment and materials must be protected during shipment and storage against physical damage, dirt, moisture, cold and rain:
 - a. Store and protect equipment in a manner that precludes damage or loss, including theft.
 - b. Protect painted surfaces with factory installed removable heavy kraft paper, sheet vinyl or equivalent.
 - c. Protect enclosures, equipment, controls, controllers, circuit protective devices, and other like items, against entry of foreign matter during installation; vacuum clean both inside and outside before testing and operating.

C. Coordinate storage.

1.9 FIELD CONDITIONS

- A. Where variations from documents are requested in accordance with Section 01 00 00, GENERAL CONDITIONS and Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, connecting work and related components must include additions or changes to equipment, components, and installation methods.

1.10 WARRANTY

A. Comply with FAR clause 52.246-21, except as follows:

1. Warranty material and equipment to be free from defects, workmanship, and remain so for a period of one year for Emergency

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-28-23

- Systems from date of final acceptance of system by Government;
provide OEM's equipment warranty document to COR.
2. Government maintenance personnel must have ability to contact OEM
for emergency maintenance and logistic assistance, remote diagnostic
testing, and assistance in resolving technical problems at any time;
contractor and OEM must provide this capability.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

- A. Coordinate systems, equipment, and materials installation with other building components.
- B. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings.
- C. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed in both exposed and un-exposed spaces.
- D. Install equipment according to manufacturers' written instructions.
- E. Install cabling, wiring, and equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. Connect equipment for ease of disconnecting, with minimum interference of adjacent other installations.
- F. Provide supplementary or miscellaneous items, appurtenances, devices and materials for a complete installation.

3.2 FIELD QUALITY CONTROL

- A. Provide minimum clearances and work required for compliance with NFPA 70, National Electrical Code (NEC), and manufacturers' instructions; comply with additional requirements indicated for access and clearances.
- B. Conduct project acceptance inspections, final completion inspections, substantial completion inspections, and acceptance testing and demonstrations after verification of system operation and completeness by Contractor.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-28-23

C. Interim Inspection:

1. Interim inspection is required at approximately 50 percent of installation.
2. Request inspection ten working days prior to interim inspection start date by notifying COR in writing; this inspection must verify equipment and system being provided adheres to installation and technical requirements of construction documents.
3. Where applicable, check each item of installed (special telecommunications system) equipment to ensure appropriate NRTL listing labels and markings are fixed in place.
4. Verify cabling terminations in telecommunications spaces and end-user Work Area Outlets (WAOs) adhere to T568B pin assignments and cabling connections are in compliance with TIA standards.
5. Visually confirm minimum performance category cable marking of backbone, horizontal, and patch cabling for both copper UTP and fiber optic cabling.
6. Review communications bonding system in each telecommunications space.
7. Review cable tray installation practices.
8. Provide results of interim inspections to COR.
9. If major or multiple deficiencies are discovered, additional interim inspections may be required until deficiencies are corrected, before permitting further system installation.
 - a. Additional inspections are scheduled at direction of COR.
 - b. Re-inspection of deficiencies noted during interim inspections, must be part of system's Final Acceptance Proof of Performance Test.
 - c. The interim inspection cannot affect the system's completion date unless directed by COR.
10. Facility COR will ensure test documents become a part of system's official documentation package.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

03-28-23

3.3 CLEANING

- A. Remove debris, rubbish, waste material, tools, construction equipment, machinery and surplus materials from project site and clean work area, prior to final inspection and acceptance of work.
- B. Put building and premises in neat and clean condition.
- C. Remove debris on a daily basis.
- D. Remove unused material, during progress of work.
- E. Perform cleaning and washing required to provide acceptable appearance and operation of equipment to satisfaction of COR.
- F. Clean exterior surface of all equipment, including concrete residue, dirt, and paint residue, after completion of project.
- G. Perform final cleaning prior to project acceptance by COR.
- H. Remove paint splatters and other spots, dirt, and debris; touch up scratches and mars of finish to match original finish.
- I. Clean devices internally using methods and materials recommended by manufacturer.
- J. Tighten wiring connectors, terminals, bus joints, and mountings, to include lugs, screws and bolts according to equipment manufacturer's published torque tightening values for equipment connectors. In absence of published connection or terminal torque values, comply with torque values specified in UL 486A-486B.

3.4 TRAINING

- A. Provide training in accordance with subsection, INSTRUCTIONS, of Section 01 00 00, GENERAL REQUIREMENTS.
- B. Provide training for equipment or system as required in each associated specification.
- C. Develop and submit training schedule for approval by COR, at least 30 days prior to planned training.

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Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

DIVISION 28

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

SECTION 28 05 00
COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This Section, Common Work Results for Electronic Safety and Security (ESS), applies to all sections of Division 28.
- B. Furnish and install fully functional electronic safety and security cabling system(s), equipment, and approved accessories in accordance with the specification section(s), drawing(s), and referenced publications. Capacities and ratings of cable and other items and arrangements for the specified items are shown on each system's required Bill of Materials (BOM) and verified on the approved system drawing(s). If there is a conflict between contract's specification(s) and drawings(s), the contract's specification requirements shall prevail.
- F. Section Includes:
 - 1. Description of Work for Electronic Security Systems,
 - 2. Electronic security equipment coordination with relating Divisions,
 - 3. Submittal Requirements for Electronic Security,
 - 4. Miscellaneous Supporting equipment and materials for Electronic Security,
 - 5. Electronic security installation requirements.

1.2 RELATED WORK

- A. Section 01 00 00 - GENERAL REQUIREMENTS. For General Requirements.
- B. Section 07 84 00 - FIRESTOPPING. Requirements for firestopping application and use.
- C. Section 08 71 00 - DOOR HARDWARE. Requirements for door installation.
- D. Section 10 14 00 - SIGNAGE. Requirements for labeling and signs.
- F. Section 26 05 11 - REQUIREMENTS FOR ELECTRICAL INSTALLATIONS. Requirements for connection of high voltage.
- G. Section 26 05 21 - LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW). Requirements for power cables.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- H. Section 26 05 33 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.
Requirements for infrastructure.
- I. Section 28 05 13 - CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY. Requirements for conductors and cables.
- J. Section 28 05 26 - GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY. Requirements for grounding of equipment.
- K. Section 28 05 28.33 - CONDUITS AND BOXES FOR ELECTRONIC SAFETY AND SECURITY. Requirements for infrastructure.
- L. Section 28 08 00 - COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY SYSTEMS. Requirements for Commissioning.
- M. Section 28 13 00 - PHYSICAL ACCESS CONTROL SYSTEMS (PACS). For physical access control integration.
- N. Section 28 23 00 - VIDEO SURVEILLANCE. Requirements for security camera systems.

1.3 DEFINITIONS

- A. AGC: Automatic Gain Control.
- B. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.
- C. BICSI: Building Industry Consulting Service International.
- D. CCD: Charge-coupled device.
- E. Central Station: A PC with software designated as the main controlling PC of the security access system. Where this term is presented with initial capital letters, this definition applies.
- F. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel section.
- G. Controller: An intelligent peripheral control unit that uses a computer for controlling its operation. Where this term is presented with an initial capital letter, this definition applies.
- H. CPU: Central processing unit.
- I. Credential: Data assigned to an entity and used to identify that entity.
- J. DGP: Data Gathering Panel - component of the Physical Access Control System capable to communicate, store and process information received

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

from readers, reader modules, input modules, output modules, and Security Management System.

- K. DTS: Digital Termination Service: A microwave-based, line-of-sight communications provided directly to the end user.
- L. EMI: Electromagnetic interference.
- M. EMT: Electric Metallic Tubing.
- N. ESS: Electronic Security System.
- O. File Server: A PC in a network that stores the programs and data files shared by users.
- P. GFI: Ground fault interrupter.
- Q. IDC: Insulation displacement connector.
- R. Identifier: A credential card, keypad personal identification number or code, biometric characteristic, or other unique identification entered as data into the entry-control database for the purpose of identifying an individual. Where this term is presented with an initial capital letter, this definition applies.
- S. I/O: Input/Output.
- T. Intrusion Zone: A space or area for which an intrusion must be detected and uniquely identified, the sensor or group of sensors assigned to perform the detection, and any interface equipment between sensors and communication link to central-station control unit.
- U. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
- V. LAN: Local area network.
- W. LCD: Liquid-crystal display.
- X. LED: Light-emitting diode.
- Y. Location: A Location on the network having a PC-to-Controller communications link, with additional Controllers at the Location connected to the PC-to-Controller link with RS-485 communications loop. Where this term is presented with an initial capital letter, this definition applies.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- Z. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
- AA. M-JPEG: Motion - Joint Photographic Experts Group.
- BB. MPEG: Moving picture experts' group.
- CC. NEC: National Electric Code
- DD. NEMA: National Electrical Manufacturers Association
- EE. NFPA: National Fire Protection Association
- FF. NTSC: National Television System Committee.
- GG. NRTL: Nationally Recognized Testing Laboratory.
- HH. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).
- II. PACS: Physical Access Control System; A system comprised of cards, readers, door controllers, servers and software to control the physical ingress and egress of people within a given space
- JJ. PC: Personal computer. This acronym applies to the Central Station, workstations, and file servers.
- KK. PCI Bus: Peripheral component interconnect; a peripheral bus providing a high-speed data path between the CPU and peripheral devices (such as monitor, disk drive, or network).
- LL. PDF: (Portable Document Format.) The file format used by the Acrobat document exchange system software from Adobe.
- MM. RCDD: Registered Communications Distribution Designer.
- NN. RFI: Radio-frequency interference.
- OO. RIGID: Rigid conduit is galvanized steel tubing, with a tubing wall that is thick enough to allow it to be threaded.
- PP. RS-232: A TIA/EIA standard for asynchronous serial data communications between terminal devices. This standard defines a 25-pin connector and certain signal characteristics for interfacing computer equipment.
- QQ. RS-485: A TIA/EIA standard for multipoint communications.
- RR. Solid-Bottom or Non-ventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal side rails, and a bottom without ventilation openings.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- SS. SMS: Security Management System - A SMS is software that incorporates multiple security subsystems (e.g., physical access control, intrusion detection, closed circuit television, intercom) into a single platform and graphical user interface.
- TT. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.
- UU. Trough or Ventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal rails and a bottom having openings sufficient for the passage of air and using 75 percent or less of the plan area of the surface to support cables.
- VV. UPS: Uninterruptible Power Supply
- WW. UTP: Unshielded Twisted Pair
- XX. Workstation: A PC with software that is configured for specific limited security system functions.

1.4 QUALITY ASSURANCE

- A. Manufacturers Qualifications: The manufacturer shall regularly and presently produce, as one of the manufacturer's principal products, the equipment and material specified for this project, and shall have manufactured the item for at least three years.
- B. Product Qualification:
1. Manufacturer's product shall have been in satisfactory operation, on three installations of similar size and type as this project, for approximately three years.
 2. The Government reserves the right to require the Contractor to submit a list of installations where the products have been in operation before approval.
- C. Contractor Qualification:
1. The Contractor or security sub-contractor shall be a licensed security Contractor with a minimum of five (5) years' experience installing and servicing systems of similar scope and complexity. The Contractor shall be an authorized regional representative of the Security Management System's (PACS) manufacturer. The Contractor shall provide four (4) current references from clients with systems of similar scope and complexity which became operational in the past

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- three (3) years. At least three (3) of the references shall be utilizing the same system components, in a similar configuration as the proposed system. The references must include a current point of contact, company or agency name, address, telephone number, complete system description, date of completion, and approximate cost of the project. The owner reserves the option to visit the reference sites, with the site owner's permission and representative, to verify the quality of installation and the references' level of satisfaction with the system. The Contractor shall provide copies of system manufacturer certification for all technicians. The Contractor shall only utilize factory-trained technicians to install, program, and service the PACS. The Contractor shall only utilize factory-trained technicians to install, terminate and service controller/field panels and reader modules. The technicians shall have a minimum of five (5) continuous years of technical experience in electronic security systems. The Contractor shall have a local service facility. The facility shall be located within [60] <insert number> miles of the project site. The local facility shall include sufficient spare parts inventory to support the service requirements associated with this contract. The facility shall also include appropriate diagnostic equipment to perform diagnostic procedures. The COR or A/E reserves the option of surveying the company's facility to verify the service inventory and presence of a local service organization.
2. The Contractor shall provide proof project superintendent with BICSI Certified Commercial Installer Level 1, Level 2, or Technician to provide oversight of the project.
 3. Cable installer must have on staff a Registered Communication Distribution Designer (RCDD) certified by Building Industry Consulting Service International. The staff member shall provide consistent oversight of the project cabling throughout design, layout, installation, termination, and testing.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

28 05 00 - 6

Common Work Results for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- D. Service Qualifications: There shall be a permanent service organization maintained or trained by the manufacturer which will render satisfactory service to this installation within four hours of receipt of notification that service is needed. Submit name and address of service organizations.

1.5 GENERAL ARRANGEMENT OF CONTRACT DOCUMENTS

- A. The Contract Documents supplement to this specification indicates approximate locations of equipment. The installation and/or locations of the equipment and devices shall be governed by the intent of the design; specification and Contract Documents, with due regard to actual site conditions, recommendations, ambient factors affecting the equipment and operations in the vicinity. The Contract Documents are diagrammatic and do not reveal all offsets, bends, elbows, components, materials, and other specific elements that may be required for proper installation. If any departure from the contract documents is deemed necessary, or in the event of conflicts, the Contractor shall submit details of such departures or conflicts in writing to the owner or owner's representative for his or her comment and/or approval before initiating work.
- B. Anything called for by one of the Contract Documents and not called for by the others shall be of like effect as if required or called by all, except if a provision clearly designed to negate or alter a provision contained in one or more of the other Contract Documents shall have the intended effect. In the event of conflicts among the Contract Documents, the Contract Documents shall take precedence in the following order: the Form of Agreement; the Supplemental General Conditions; the Special Conditions; the Specifications with attachments; and the drawings.

1.6 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. The Government's approval shall be obtained for all equipment and material before delivery to the job site. Delivery, storage or

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

28 05 00 - 7

Common Work Results for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

installation of equipment or material which has not had prior approval will not be permitted at the job site.

- C. Submittals for individual systems and equipment assemblies which consist of more than one item or component shall be made for the system or assembly as a whole. Partial submittals will not be considered for approval.

1. Mark the submittals, "SUBMITTED UNDER SECTION_____".
2. Submittals shall be marked to show specification reference including the section and paragraph numbers.
3. Submit each section separately.

- D. The submittals shall include the following:

1. Information that confirms compliance with contract requirements.
Include the manufacturer's name, model or catalog numbers, catalog information, technical data sheets, shop drawings, pictures, nameplate data and test reports as required.
2. Parts list which shall include those replacement parts recommended by the equipment manufacturer, quantity of parts, current price and availability of each part.

- E. Submittals shall be in full compliance of the Contract Documents. All submittals shall be provided in accordance with this section.

Submittals lacking the breadth or depth these requirements will be considered incomplete and rejected. Submissions are considered multidisciplinary and shall require coordination with applicable divisions to provide a complete and comprehensive submission package. All submittals shall include adequate descriptive literature, catalog cuts, shop drawings and other data necessary for the Government to ascertain that the proposed equipment and materials comply with specification requirements. Catalog cuts submitted for approval shall be legible and clearly identify equipment being submitted. Additional general provisions are as follows:

1. The Contractor shall schedule submittals in order to maintain the project schedule. For coordination drawings refer to Specification Section 01 33 10 - Design Submittal Procedures, which outline basic

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

28 05 00 - 8

Common Work Results for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- submittal requirements and coordination. Section 01 33 10 shall be used in conjunction with this section.
2. The Contractor shall identify variations from requirements of Contract Documents and state product and system limitations, which may be detrimental to successful performance of the completed work or system.
 3. Each package shall be submitted at one (1) time for each review and include components from applicable disciplines (e.g., electrical work, architectural finishes, door hardware, etc.) which are required to produce an accurate and detailed depiction of the project.
 4. Manufacturer's information used for submittal shall have pages with items for approval tagged, items on pages shall be identified, and capacities and performance parameters for review shall be clearly marked through use of an arrow or highlighting. Provide space for COR or A/E and Contractor review stamps.
 5. Technical Data Drawings shall be in the latest version of AutoCAD®, drawn accurately, and in accordance with VA CAD Standards CAD Standard Application Guide, and VA BIM Guide. FREEHAND SKETCHES OR COPIED VERSIONS OF THE CONSTRUCTION DOCUMENTS WILL NOT BE ACCEPTED. The Contractor shall not reproduce Contract Documents or copy standard information as the basis of the Technical Data Drawings. If departures from the technical data drawings are subsequently deemed necessary by the Contractor, details of such departures and the reasons thereof shall be submitted in writing to the COR or A/E for approval before the initiation of work.
 6. Packaging: The Contractor shall organize the submissions according to the following packaging requirements.
 - a. Binders: For each manual, provide heavy duty, commercial quality, durable three (3) ring vinyl covered loose leaf binders, sized to receive 8.5 x 11 in paper, and appropriate capacity to accommodate the contents. Provide a clear plastic sleeve on the spine to hold labels describing the contents. Provide pockets in the covers to receive folded sheets.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- 1) Where two (2) or more binders are necessary to accommodate data, correlate data in each binder into related groupings according to the Project Manual table of contents. Cross-referencing other binders where necessary to provide essential information for communication of proper operation and/or maintenance of the component or system.
- 2) Identify each binder on the front and spine with printed binder title, Project title or name, and subject matter covered. Indicate the volume number if applicable.
- b. Dividers: Provide heavy paper dividers with celluloid tabs for each Section. Mark each tab to indicate contents.
- c. Protective Plastic Jackets: Provide protective transparent plastic jackets designed to enclose diagnostic software for computerized electronic equipment.
- d. Text Material: Where written material is required as part of the manual use the manufacturer's standard printed material, or if not available, specially prepared data, neatly typewritten on 8.5 inches by 11 inches 20-pound white bond paper.
- e. Drawings: Where drawings and/or diagrams are required as part of the manual, provide reinforced punched binder tabs on the drawings and bind them with the text.
 - 1) Where oversized drawings are necessary, fold the drawings to the same size as the text pages and use as a foldout.
 - 2) If drawings are too large to be used practically as a foldout, place the drawing, neatly folded, in the front or rear pocket of the binder. Insert a type written page indicating the drawing title, description of contents and drawing location at the appropriate location of the manual.
 - 3) Drawings shall be sized to ensure details and text is of legible size. Text shall be no less than 1/16" tall.
- f. Manual Content: Submit in accordance with Section 01 00 00, GENERAL REQUIREMENTS.
 - 1) Maintenance and Operation Manuals: Submit as required for systems and equipment specified in the technical sections.

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

28 05 00 - 10

Common Work Results for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

Furnish four copies, bound in hardback binders, (manufacturer's standard binders) or an approved equivalent. Furnish one complete manual as specified in the technical section but in no case later than prior to performance of systems or equipment test and furnish the remaining manuals prior to contract completion.

- 2) Inscribe the following identification on the cover: the words "MAINTENANCE AND OPERATION MANUAL," the name and location of the system, equipment, building, name of Contractor, and contract number. Include in the manual the names, addresses, and telephone numbers of each subcontractor installing the system or equipment and the local representatives for the system or equipment.
- 3) The manuals shall include:
 - a) Internal and interconnecting wiring and control diagrams with data to explain detailed operation and control of the equipment.
 - b) A control sequence describing start-up, operation, and shutdown.
 - c) Description of the function of each principal item of equipment.
 - d) Installation and maintenance instructions.
 - e) Safety precautions.
 - f) Diagrams and illustrations.
 - g) Testing methods.
 - h) Performance data.
 - i) Pictorial "exploded" parts list with part numbers. Emphasis shall be placed on the use of special tools and instruments. The list shall indicate sources of supply, recommended spare parts, and name of servicing organization.
 - j) Appendix; list qualified permanent servicing organizations for support of the equipment, including addresses and certified qualifications.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- g. Binder Organization: Organize each manual into separate sections for each piece of related equipment. At a minimum, each manual shall contain a title page, table of contents, copies of Product Data supplemented by drawings and written text, and copies of each warranty, bond, certifications, and service Contract issued. Refer to Group I through V Technical Data Package Submittal requirements for required section content.
- h. Title Page: Provide a title page as the first sheet of each manual to include the following information: project name and address, subject matter covered by the manual, name and address of the Project, date of the submittal, name, address, and telephone number of the Contractor, and cross references to related systems in other operating and/or maintenance manuals.
- i. Table of Contents: After the title page, include a type written table of contents for each volume, arranged systematically according to the Project Manual format. Provide a list of each product included, identified by product name or other appropriate identifying symbols and indexed to the content of the volume. Where more than one (1) volume is required to hold data for a particular system, provide a comprehensive table of contents for all volumes in each volume of the set.
- j. General Information Section: Provide a general information section immediately following the table of contents, listing each product included in the manual, identified by product name. Under each product, list the name, address, and telephone number of the installer and maintenance Contractor. In addition, list a local source for replacement parts and equipment.
- k. Drawings: Provide specially prepared drawings where necessary to supplement the manufacturers printed data to illustrate the relationship between components of equipment or systems or provide control or flow diagrams. Coordinate these drawings with information contained in Project Record Drawings to assure correct illustration of the completed installation.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- l. Manufacturer's Data: Where manufacturer's standard printed data is included in the manuals, include only those sheets that are pertinent to the part or product installed. Mark each sheet to identify each part or product included in the installation. Where more than one (1) item in tabular format is included, identify each item, using appropriate references from the Contract Documents. Identify data that is applicable to the installation and delete references to information which is not applicable.
 - m. Where manufacturer's standard printed data is not available and the information is necessary for proper operation and maintenance of equipment or systems, or it is necessary to provide additional information to supplement the data included in the manual, prepare written text to provide the necessary information. Organize the text in a consistent format under a separate heading for different procedures. Where necessary, provide a logical sequence of instruction for each operating or maintenance procedure. Where similar or more than one product is listed on the submittal the Contractor shall differentiate by highlighting the specific product to be utilized.
 - n. Calculations: Provide a section for circuit and panel calculations.
 - o. Loading Sheets: Provide a section for DGP Loading Sheets.
 - p. Certifications: Provide section for Contractor's manufacturer certifications.
7. Contractor Review: Review submittals prior to transmittal. Determine and verify field measurements and field construction criteria. Verify manufacturer's catalog numbers and conformance of submittal with requirements of contract documents. Return non-conforming or incomplete submittals with requirements of the work and contract documents. Apply Contractor's stamp with signature certifying the review and verification of products occurred, and the field dimensions, adjacent construction, and coordination of

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

information is in accordance with the requirements of the contract documents.

8. Resubmission: Revise and resubmit submittals as required within 15 calendar days of return of submittal. Make resubmissions under procedures specified for initial submittals. Identify all changes made since previous submittal.

9. Product Data: Within 15 calendar days after execution of the contract, the Contractor shall submit for approval a complete list of all of major products proposed for use. The data shall include name of manufacturer, trade name, model number, the associated contract document section number, paragraph number, and the referenced standards for each listed product.

F. Group 1 Technical Data Package: Group I Technical Data Package shall be one submittal consisting of the following content and organization. Refer to VA Special Conditions Document for drawing format and content requirements. The data package shall include the following:

1. Section I - Drawings:

a. General - Drawings shall conform to VA CAD Standards Guide. All text associated with security details shall be 1/8" tall and meet VA text standard for AutoCAD™ drawings.

b. Cover Sheet - Cover sheet shall consist of Project Title and Address, Project Number, Area and Vicinity Maps.

c. General Information Sheets - General Information Sheets shall consist of General Notes, Abbreviations, Symbols, Wire and Cable Schedule, Project Phasing, and Sheet Index.

d. Floor Plans - Floor plans shall be produced from the Architectural backgrounds issued in the Construction Documents. The contractor shall receive floor plans from the prime A/E to develop these drawing sets. Security devices shall be placed on drawings in scale. All text associated with security details shall be 1/8" tall and meet VA text standard for AutoCAD™ drawings. Floor plans shall identify the following:

1) Security devices by symbol,

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- 2) The associated device point number (derived from the loading sheets),
- 3) Wire & cable types and counts
- 4) Conduit sizing and routing
- 5) Conduit riser systems
- 6) Device and area detail call outs
- e. Architectural details - Architectural details shall be produced for each device mounting type (door details for EECS and IDS, Intrusion Detection system (motion sensor, vibration, microwave Motion Sensor and Camera mounting,
- f. Riser Diagrams - Contractor shall provide a riser diagram indicating riser architecture and distribution of the SMS throughout the facility (or area in scope).
- g. Block Diagrams - Contractor shall provide a block diagram for the entire system architecture and interconnections with SMS subsystems. Block diagram shall identify SMS subsystem (e.g., electronic entry control, intrusion detection, closed circuit television, intercom, and other associated subsystems) integration, and data transmission and media conversion methodologies.
- h. Interconnection Diagrams - Contractor shall provide interconnection diagram for each sensor, and device component. Interconnection diagram shall identify termination locations, standard wire detail to include termination schedule. Diagram shall also identify interfaces to other systems such as elevator control, fire alarm systems, and security management systems.
- i. Security Details:
 - 1) Panel Assembly Detail - For each panel assembly, a panel assembly details shall be provided identifying individual panel component size and content.
 - 2) Panel Details - Provide security panel details identify general arrangement of the security system components, backboard size, wire through size and location, and power circuit requirements.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- 3) Device Mounting Details - Provide mounting detailed drawing for each security device (physical access control system, intrusion detection, video surveillance and assessment, and intercom systems) for each type of wall and ceiling configuration in project. Device details shall include device, mounting detail, wiring and conduit routing.
- 4) Details of connections to power supplies and grounding
- 5) Details of surge protection device installation
- 6) Sensor detection patterns - Each system sensor shall have associated detection patterns.
- k. Door Schedule - A door schedule shall be developed for each door equipped with electronic security components. At a minimum, the door schedule shall be coordinated with Division 08 work and include the following information:
 - 1) Item Number
 - 2) Door Number (Derived from A/E Drawings)
 - 3) Floor Plan Sheet Number
 - 4) Standard Detail Number
 - 5) Door Description (Derived from Loading Sheets)
 - 6) Data Gathering Panel Input Number
 - 7) Door Position or Monitoring Device Type & Model Number
 - 8) Lock Type, Model Number & Power Input/Draw (standby/active)
 - 9) Card Reader Type & Model Number
 - 10) Shunting Device Type & Model Number
 - 11) Sounder Type & Model Number
 - 12) Manufacturer
 - 13) Misc. devices as required
 - a) Delayed Egress Type & Model Number
 - b) Intercom
 - c) Camera
 - d) Electric Transfer Hinge
 - e) Electric Pass-through device
 - 14) Remarks column indicating special notes or door configurations

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

2. Camera Schedule - A camera schedule shall be developed for each camera. Contractors shall coordinate with the COR or A/E to determine camera starting numbers and naming conventions. All drawings shall identify wire and cable standardization methodology. Color coding of all wiring conductors and jackets is required and shall be communicated consistently throughout the drawings package submittal. At a minimum, the camera schedule shall include the following information:
 - a. Item Number
 - b. Camera Number
 - c. Naming Conventions
 - d. Description of Camera Coverage
 - e. Camera Location
 - f. Floor Plan Sheet Number
 - g. Camera Type
 - h. Mounting Type
 - i. Standard Detail Reference
 - j. Power Input & Draw
 - k. Power Panel Location
 - l. Remarks Column for Camera
3. Section II - Data Gathering Panel Documentation Package
 - a. Contractor shall provide Data Gathering Panel (DGP) input and output documentation packages for review at the Shop Drawing submittal stage and also with the as-built documentation package. The documentation packages shall be provided in both printed and magnetic form at both review stages.
 - b. The Contractor shall provide loading sheet documentation package for the associated DGP, including input and output boards for all field panels associated with the project. Documentation shall be provided in current version Microsoft Excel spreadsheets following the format currently utilized by VA. A separate spreadsheet file shall be generated for each DGP and associated field panels.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- c. The spreadsheet names shall follow a sequence that shall display the spreadsheets in numerical order according to the DGP system number. The spreadsheet shall include the prefix in the file name that uniquely identifies the project site. The spreadsheet shall detail all connected items such as card readers, alarm inputs, and relay output connections. The spreadsheet shall include an individual section (row) for each panel input, output and card reader. The spreadsheet shall automatically calculate the system numbers for card readers, inputs, and outputs based upon data entered in initialization fields.
- d. All entries must be verified against the field devices. Copies of the floor plans shall be forwarded under separate cover.
- e. The DGP spreadsheet shall include an entry section for the following information:
 - 1) DGP number
 - 2) First Reader Number
 - 3) First Monitor Point Number
 - 4) First Relay Number
 - 5) DGP, input or output Location
 - 6) DGP Chain Number
 - 7) DGP Cabinet Tamper Input Number
 - 8) DGP Power Fail Input Number
 - 9) Number of Monitor Points Reserved for Expansion Boards
 - 10) Number of Control Points (Relays) Reserved for Expansion Boards
- f. The DGP, input module and output module spreadsheets shall automatically calculate the following information based upon the associated entries in the above fields:
 - 1) System Numbers for Card Readers
 - 2) System Numbers for Monitor Point Inputs
 - 3) System Numbers for Control Points (Relays)
 - 4) Next DGP or input module First Monitor Point Number
 - 5) Next DGP or output module First Control Point Number

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

g. The DGP spreadsheet shall provide the following information for each card reader:

- 1) DGP Reader Number
- 2) System Reader Number
- 3) Cable ID Number
- 4) Description Field (Room Number)
- 5) Description Field (Device Type i.e.: In Reader, Out Reader, etc.)
- 6) Description Field
- 7) DGP Input Location
- 8) Date Test
- 9) Date Passed
- 10) Cable Type
- 11) Camera Numbers (of cameras viewing the reader location)

h. The DGP and input module spreadsheet shall provide the following information for each monitor point (alarm input).

- 1) DGP Monitor Point Input Number
- 2) System Monitor Point Number
- 3) Cable ID Number
- 4) Description Field (Room Number)
- 5) Description Field (Device Type i.e.: Door Contact, Motion Detector, etc.)
- 7) DGP or input module Input Location
- 8) Date Test
- 9) Date Passed
- 10) Cable Type
- 11) Camera Numbers (of associated alarm event preset call-ups)

i. The DGP and output module spreadsheet shall provide the following information for each control point (output relay).

- 1) DGP Control Point (Relay) Number
- 2) System (Control Point) Number
- 3) Cable ID Number
- 4) Description Field (Room Number)
- 5) Description Field (Device: Lock Control, Local Sounder, etc.)

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

28 05 00 - 19

Common Work Results for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- 6) Description Field
- 7) DGP or OUTPUT MODULE Output Location
- 8) Date Test
- 9) Date Passed Cable Type
- 10) Camera Number (of associated alarm event preset call-ups)
- j. The DGP, input module and output module spreadsheet shall include the following information or directions in the header and footer:
 - 1) Header
 - a) DGP Input and Output Worksheet
 - b) Enter Beginning Reader, Input, and Output Starting Numbers and Sheet Will Automatically Calculate the Remaining System Numbers.
 - 2) Footer
 - a) File Name
 - b) Date Printed
 - c) Page Number
- 5. Section IV - Manufacturers' Data: The data package shall include manufacturers' data for all materials and equipment, including sensors, local processors and console equipment provided under this specification.
- 6. Section V - System Description and Analysis: The data package shall include system descriptions, analysis, and calculations used in sizing equipment required by these specifications. Descriptions and calculations shall show how the equipment will operate as a system to meet the performance requirements of this specification. The data package shall include the following:
 - a. Central processor memory size; communication speed and protocol description; rigid disk system size and configuration; flexible disk system size and configuration; back-up media size and configuration; alarm response time calculations; command response time calculations; start-up operations; expansion capability and method of implementation; sample copy of each report specified; and color photographs representative of typical graphics.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- b. Software Data: The data package shall consist of descriptions of the operation and capability of the system, and application software as specified.
- c. Overall System Reliability Calculations: The data package shall include all manufacturers' reliability data and calculations required to show compliance with the specified reliability.
- 7. Section VI - Certifications & References: All specified manufacturer's certifications shall be included with the data package. Contractor shall provide Project references as outlined in Paragraph 1.4 "Quality Assurance".

G. Group II Technical Data Package

- 1. The Contractor shall prepare a report of "Current Site Conditions" and submit a report to the COR and A/E documenting changes to the site, particularly those conditions that affect performance of the system to be installed. The Contractor shall provide specification sheets, or written functional requirements to support the findings, and a cost estimate to correct those site changes or conditions which affect the installation of the system or its performance. The Contractor shall not correct any deficiency without written permission from the COTR.
- 2. System Configuration and Functionality: The contractor shall provide the results of the meeting with VA to develop system requirements and functionality including but not limited to:
 - a. Baseline configuration
 - b. Access levels
 - c. Schedules (intrusion detection, physical access control, holidays, etc.)
 - d. Badge database
 - e. System monitoring and reporting (unit level and central control)
 - f. Naming conventions and descriptors

H. Group III Technical Data Package

- 1. Development of Test Procedures: The Contractor will prepare performance test procedures for the system testing. The test procedures shall follow the format of the VA Testing procedures and

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

be customized to the contract requirements. The Contractor will deliver the test procedures to the COR or A/E for approval at least 60 calendar days prior to the requested test date.

I. Group IV Technical Data Package

1. Performance Verification Test

- a. Based on the successful completion of the pre-delivery test, the Contractor shall finalize the test procedures and report forms for the performance verification test (PVT) and the endurance test. The PVT shall follow the format, layout and content of the pre-delivery test. The Contractor shall deliver the PVT and endurance test procedures to the COR and A/E for approval. The Contractor may schedule the PVT after receiving written approval of the test procedures. The Contractor shall deliver the final PVT and endurance test reports within 14 calendar days from completion of the tests. Refer to Part 3 of this section for System Testing and Acceptance requirements.

2. Training Documentation

- a. New Facilities and Major Renovations: Familiarization training shall be provided for new equipment or systems. Training can include site familiarization training for VA technicians and administrative personnel. Training shall include general information on new system layout including closet locations, turnover of the completed system including all documentation, including manuals, software, key systems, and full system administration rights. Lesson plans and training manuals training shall be oriented to type of training to be provided.

b. New Unit Control Room:

- 1) Provide the security personnel with training in the use, operation, and maintenance of the entire control room system (Unit Control and Equipment Rooms). The training documentation must include the operation and maintenance. The first of the training sessions shall take place prior to system turnover and the second immediately after turnover.

Coordinate the training sessions with the Owner. Completed

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

28 05 00 - 22

Common Work Results for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

classroom sessions will be witnessed and documented by the Architect/Engineer and approved by the COR and A/E.

Instruction is not to begin until the system is operational as designed.

- 2) The training documents will cover the operation and the maintenance manuals and the control console operators' manuals and service manuals in detail, stressing all important operational and service diagnostic information necessary for the maintenance and operations personnel to efficiently use and maintain all systems.
- 3) Provide an illustrated control console operator's manual and service manual. The operator's manual shall be written in laymen's language and printed so as to become a permanent reference document for the operators, describing all control panel switch operations, graphic symbol definitions and all indicating functions and a complete explanation of all software.
- 4) The service manual shall be written in laymen's language and printed so as to become a permanent reference document for maintenance personnel, describing how to run internal self-diagnostic software programs, troubleshoot head end hardware and field devices with a complete scenario simulation of all possible system malfunctions and the appropriate corrective measures.
- 5) Provide a professional color DVD instructional recording of all the operational procedures described in the operator's manual. All charts used in the training session shall be clearly presented on the video. Any DVD found to be inferior in recording or material content shall be reproduced at no cost until an acceptable DVD is submitted. Provide four copies of the training DVD, one to the architect/engineer and three to the owner.

3. System Configuration and Data Entry:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- a. The contractor is responsible for providing all system configuration and data entry for the SMS and subsystems (e.g., video matrix switch, intercom, digital video recorders, network video recorders). All data entry shall be performed per VA standards & guidelines. The Contractor is responsible for participating in all meetings with the client to compile the information needed for data entry. These meetings shall be established at the beginning of the project and incorporated into the project schedule as a milestone task. The contractor shall be responsible for all data collection, data entry, and system configuration. The contractor shall collect, enter, & program and/or configure the following components:
 - 1) Physical Access control system components,
 - 2) All intrusion detection system components,
 - 3) Video surveillance, control and recording systems,
 - 4) Intercom systems components,
 - 5) All other security subsystems shown in the contract documents.
- b. The Contractor is responsible for compiling the card access database for the VA employees, including programming reader configurations, access shifts, schedules, exceptions, card classes and card enrollment databases.
- c. Refer to Part 3 for system programming requirements and planning guidelines.
4. Graphics: Based on CAD as-built drawings developed for the construction project, create all map sets showing locations of all alarms and field devices. Graphical maps of all alarm points installed under this contract including perimeter and exterior alarm points shall be delivered with the system. The Contractor shall create and install all graphics needed to make the system operational. The Contractor shall utilize data from the contract documents, Contractor's field surveys, and all other pertinent information in the Contractor's possession to complete the graphics. The Contractor shall identify and request from the COTR, any additional data needed to provide a complete graphics package.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

28 05 00 - 24

Common Work Results for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

Graphics shall have sufficient level of detail for the system operator to assess the alarm. The Contractor shall supply hard copy, color examples at least 203.2 x 254 mm (8 x 10 in) of each type of graphic to be used for the completed Security system. The graphics examples shall be delivered to the COR and A/E for review and approval at least 90 calendar days prior to the scheduled date the Contractor requires them.

J. In addition to the requirement Package: Final copies of the manuals shall be delivered to the COR and A/E as part of the acceptance test. The draft copy used during site testing shall be updated with any changes required prior to final delivery of the manuals. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each sub-contractor installing equipment or systems, as well as the nearest service representatives for each item of equipment for each system. The manuals shall include a table of contents and tab sheets. Tab sheets shall be placed at the beginning of each chapter or section and at the beginning of each appendix. The final copies delivered after completion of the endurance test shall include all modifications made during installation, checkout, and acceptance. Six (6) hard-copies and one (1) soft copy of each item listed below shall be delivered as a part of final systems acceptance.

1. Functional Design Manual: The functional design manual shall identify the operational requirements for the entire system and explain the theory of operation, design philosophy, and specific functions. A description of hardware and software functions, interfaces, and requirements shall be included for all system operating modes. Manufacturer developed literature may be used; however, shall be produced to match the project requirements.
2. Equipment Manual: A manual describing all equipment furnished including:
 - a. General description and specifications; installation and checkout procedures; equipment electrical schematics and layout drawings; system schematics and layout drawings; alignment and calibration

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

procedures; manufacturer's repair list indicating sources of supply; and interface definition.

3. Software Manual: The software manual shall describe the functions of all software and include all other information necessary to enable proper loading, testing, and operation. The manual shall include:
 - a. Definition of terms and functions; use of system and applications software; procedures for system initialization, start-up, and shutdown; alarm reports; reports generation, database format and data entry requirements; directory of all disk files; and description of all communications protocols including data formats, command characters, and a sample of each type of data transfer.
4. Operator's Manual: The operator's manual shall fully explain all procedures and instructions for the operation of the system, including:
 - a. Computers and peripherals; system start-up and shutdown procedures; use of system, command, and applications software; recovery and restart procedures; graphic alarm presentation; use of report generator and generation of reports; data entry; operator commands' alarm messages, and printing formats; and system access requirements.
5. Maintenance Manual: The maintenance manual shall include descriptions of maintenance for all equipment including inspection, recommend schedules, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.
6. Spare Parts & Components Data: At the conclusion of the Contractor's work, the Contractor shall submit to the COR and A/E a complete list of the manufacturer's recommended spare parts and components required to satisfactorily maintain and service the systems, as well as unit pricing for those parts and components.
7. Operation, Maintenance & Service Manuals: The Contractor shall provide two (2) complete sets of operating and maintenance manuals in the form of an instructional manual for use by the VA Security

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

Guard Force personnel. The manuals shall be organized into suitable sets of manageable size. Where possible, assemble instructions for similar equipment into a single binder. If multiple volumes are required, each volume shall be fully indexed and coordinated.

8. Equipment and Systems Maintenance Manual: The Contractor shall provide the following descriptive information for each piece of equipment, operating system, and electronic system:
 - a. Equipment and/or system function.
 - b. Operating characteristics.
 - c. Limiting conditions.
 - d. Performance curves.
 - e. Engineering data and test.
 - f. Complete nomenclature and number of replacement parts.
 - g. Provide operating and maintenance instructions including assembly drawings and diagrams required for maintenance and a list of items recommended to stock as spare parts.
 - h. Provide information detailing essential maintenance procedures including the following: routine operations, troubleshooting guide, disassembly, repair and re-assembly, alignment, adjusting, and checking.
 - i. Provide information on equipment and system operating procedures, including the following: start-up procedures, routine and normal operating instructions, regulation and control procedures, instructions on stopping, shutdown and emergency instructions, required sequences for electric and electronic systems, and special operating instructions.
 - j. Manufacturer equipment and systems maintenance manuals are permissible.
9. Project Redlines: During construction, the Contractor shall maintain an up-to-date set of construction redlines detailing current location and configuration of the project components. The redline documents shall be marked with the words 'Master Redlines' on the cover sheet and be maintained by the Contractor in the project office. The Contractor will provide access to redline

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

28 05 00 - 27

Common Work Results for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- documents anytime during the project for review and inspection by the COR and A/E or authorized Office of Protection Services representative. Master redlines shall be neatly maintained throughout the project and secured under lock and key in the contractor's onsite project office. Any project component or assembly that is not installed in strict accordance with the drawings shall be so noted on the drawings. Prior to producing Record Construction Documents, the contractor will submit the Master Redline document to the COR and A/E for review and approval of all changes or modifications to the documents. Each sheet shall have COR and A/E initials indicating authorization to produce "As Built" documents. Field drawings shall be used for data gathering & field changes. These changes shall be made to the master redline documents daily. Field drawings shall not be considered "master redlines".
10. Record Specifications: The Contractor shall maintain one (1) copy of the Project Specifications, including addenda and modifications issued, for Project Record Documents. The Contractor shall mark the Specifications to indicate the actual installation where the installation varies substantially from that indicated in the Contract Specifications and modifications issued. (Note related Project Record Drawing information where applicable). The Contractor shall pay particular attention to substitutions, selection of product options, and information on concealed installations that would be difficult to identify or measure and record later. Upon completion of the mark ups, the Contractor shall submit record Specifications to the COTR. As with master relines, Contractor shall maintain record specifications for COR and A/E review and inspection at any time.
11. Record Product Data: The Contractor shall maintain one (1) copy of each Product Data submittal for Project Record Document purposes. The Data shall be marked to indicate the actual product installed where the installation varies substantially from that indicated in the Product Data submitted. Significant changes in the product

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

delivered to the site and changes in manufacturer's instructions and recommendations for installation shall be included. Particular attention will be given to information on concealed products and installations that cannot be readily identified or recorded later. Note related Change Orders and mark up of Record Construction Documents, where applicable. Upon completion of mark up, submit a complete set of Record Product Data to the COTR.

12. Miscellaneous Records: The Contractor shall maintain one (1) copy of miscellaneous records for Project Record Document purposes. Refer to other Specifications for miscellaneous record-keeping requirements and submittals concerning various construction activities. Before substantial completion, complete miscellaneous records and place in good order, properly identified and bound or filed, ready for use and reference. Categories of requirements resulting in miscellaneous records include a minimum of the following:

- a. Certificates received instead of labels on bulk products.
- b. Testing and qualification of tradesmen. ("Contractor's Qualifications")
- c. Documented qualification of installation firms.
- d. Load and performance testing.
- e. Inspections and certifications.
- f. Final inspection and correction procedures.
- g. Project schedule

13. Record Construction Documents (Record As-Built)

- a. Upon project completion, the contractor shall submit the project master redlines to the COR and A/E prior to development of Record construction documents. The COR and A/E shall be given a minimum of a thirty (30) day review period to determine the adequacy of the master redlines. If the master redlines are found suitable by the COR and A/E, the COR and A/E will initial and date each sheet and turn redlines over to the contractor for as built development.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- b. The Contractor shall provide the COR and A/E a complete set of "as-built" drawings and original master redlined marked "as-built" blue-line in the latest version of AutoCAD drawings unlocked on CD or DVD. The as-built drawing shall include security device number, security closet connection location, data gathering panel number, and input or output number as applicable. All corrective notations made by the Contractor shall be legible when submitted to the COTR. If, in the opinion of the COTR, any redlined notation is not legible, it shall be returned to the Contractor for re-submission at no extra cost to the Owner. The Contractor shall organize the Record Drawing sheets into manageable sets bound with durable paper cover sheets with suitable titles, dates, and other identifications printed on the cover. The submitted as built shall be in editable formats and the ownership of the drawings shall be fully relinquished to the owner.
- c. Where feasible, the individual or entity that obtained record data, whether the individual or entity is the installer, sub-contractor, or similar entity, is required to prepare the mark up on Record Drawings. Accurately record the information in a comprehensive drawing technique. Record the data when possible after it has been obtained. For concealed installations, record and check the mark up before concealment. At the time of substantial completion, submit the Record Construction Documents to the COTR. The Contractor shall organize into bound and labeled sets for the COTR's continued usage. Provide device, conduit, and cable lengths on the conduit drawings. Exact in-field conduit placement/routings shall be shown. All conduits shall be illustrated in their entire length from termination in security closets; no arrowed conduit runs shall be shown. Pull box and junction box sizes are to be shown if larger than 100mm (4 inch).
- L. Approvals will be based on complete submission of manuals together with shop drawings.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- M. After approval and prior to installation, furnish the COR and A/E with one sample of each of the following:
1. A 300 mm (12 inch) length of each type and size of wire and cable along with the tag from the coils of reels from which the samples were taken.
 2. Each type of conduit and pathway coupling, bushing, and termination fitting.
 3. Conduit hangers, clamps and supports.
 4. Duct sealing compound.
- N. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 28 08 00 COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY SYSTEMS.

1.7 APPLICABLE PUBLICATIONS

- A. The publications listed below (including amendments, addenda, revisions, supplement, and errata) form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American National Standards Institute (ANSI)/ International Code Council (ICC):
- A117.1 Standard on Accessible and Usable Buildings and Facilities
- C. American National Standards Institute (ANSI)/ Security Industry Association (SIA):
- AC-03 Access Control: Access Control Guideline Dye Sublimation Printing Practices for PVC Access Control Cards
- CP-01-00 Control Panel Standard-Features for False Alarm Reduction
- PIR-01-00 Passive Infrared Motion Detector Standard - Features for Enhancing False Alarm Immunity
- TVAC-01 CCTV to Access Control Standard - Message Set for System Integration

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

D. American National Standards Institute (ANSI)/Electronic Industries
Alliance (EIA):

330-09 Electrical Performance Standards for CCTV
Cameras

375A-76 Electrical Performance Standards for CCTV
Monitors

E. American National Standards Institute (ANSI):

ANSI S3.2-99 Method for measuring the Intelligibility of
Speech over Communications Systems

F. American Society for Testing and Materials (ASTM)

B1-07 Standard Specification for Hard-Drawn Copper
Wire

B3-07 Standard Specification for Soft or Annealed
Copper Wire

B8-04 Standard Specification for Concentric-Lay-
Stranded Copper Conductors, Hard, Medium-Hard,
or Soft

C1238-97 (R03) Standard Guide for Installation of Walk-Through
Metal Detectors

D2301-04 Standard Specification for Vinyl Chloride
Plastic Pressure Sensitive Electrical
Insulating Tape

G. Architectural Barriers Act (ABA), 1968

H. Department of Justice: American Disability Act (ADA)

28 CFR Part 36-2010 ADA Standards for Accessible Design

I. Department of Veterans Affairs:

VHA National CAD Standard Application Guide, 2006

VA BIM Guide, V1.0 10

J. Federal Communications Commission (FCC):

(47 CFR 15) Part 15 Limitations on the Use of Wireless
Equipment/Systems

K. Federal Information Processing Standards (FIPS):

FIPS-201-1 Personal Identity Verification (PIV) of Federal
Employees and Contractors

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

28 05 00 - 32

Common Work Results for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

L. Federal Specifications (Fed. Spec.):

A-A-59544-08 Cable and Wire, Electrical (Power, Fixed
Installation)

M. Government Accountability Office (GAO):

GAO-03-8-02 Security Responsibilities for Federally Owned
and Leased Facilities

N. Homeland Security Presidential Directive (HSPD):

HSPD-12 Policy for a Common Identification Standard for
Federal Employees and Contractors

O. Institute of Electrical and Electronics Engineers (IEEE):

81-1983 IEEE Guide for Measuring Earth Resistivity,
Ground Impedance, and Earth Surface Potentials
of a Ground System

802.3af-08 Power over Ethernet Standard

802.3at-09 Power over Ethernet (PoE) Plus Standard

C2-07 National Electrical Safety Code

C62.41-02 IEEE Recommended Practice on Surge Voltages in
Low-Voltage AC Power Circuits

C95.1-05 Standards for Safety Levels with Respect to
Human Exposure in Radio Frequency
Electromagnetic Fields

P. International Organization for Standardization (ISO):

7810 Identification cards - Physical characteristics

7811 Physical Characteristics for Magnetic Stripe
Cards

7816-1 Identification cards - Integrated circuit(s)
cards with contacts - Part 1: Physical
characteristics

7816-2 Identification cards - Integrated circuit cards
- Part 2: Cards with contacts -Dimensions and
location of the contacts

7816-3 Identification cards - Integrated circuit cards
- Part 3: Cards with contacts - Electrical
interface and transmission protocols

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- 7816-4 Identification cards - Integrated circuit cards
- Part 11: Personal verification through
biometric methods
- 7816-10 Identification cards - Integrated circuit cards
- Part 4: Organization, security and commands
for interchange
- 14443 Identification cards - Contactless integrated
circuit cards; Contactless Proximity Cards
Operating at 13.56 MHz in up to 5 inches
distance
- 15693 Identification cards -- Contactless integrated
circuit cards - Vicinity cards; Contactless
Vicinity Cards Operating at 13.56 MHz in up to
50 inches distance
- 19794 Information technology - Biometric data
interchange formats
- Q. National Electrical Contractors Association
303-2005 Installing Closed Circuit Television (CCTV)
Systems
- R. National Electrical Manufacturers Association (NEMA):
250-08 Enclosures for Electrical Equipment (1000 Volts
Maximum)
- TC-3-04 PVC Fittings for Use with Rigid PVC Conduit and
Tubing
- FB1-07 Fittings, Cast Metal Boxes and Conduit Bodies
for Conduit, Electrical Metallic Tubing and
Cable
- S. National Fire Protection Association (NFPA):
70-11 National Electrical Code (NEC)
- 731-08 Standards for the Installation of Electric
Premises Security Systems
- 99-2005 Health Care Facilities
- T. National Institute of Justice (NIJ)

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

0601.02-03 Standards for Walk-Through Metal Detectors for
use in Weapons Detection

0602.02-03 Hand-Held Metal Detectors for Use in Concealed
Weapon and Contraband Detection

U. National Institute of Standards and Technology (NIST):

IR 6887 V2.1 Government Smart Card Interoperability
Specification (GSC-IS)

Special Pub 800-37 Guide for Applying the Risk Management
Framework to Federal Information Systems

Special Pub 800-63 Electronic Authentication Guideline

Special Pub 800-73-3 ...Interfaces for Personal Identity Verification
(4 Parts)

.....Pt. 1- End Point PIV Card Application
Namespace, Data Model & Representation

.....Pt. 2- PIV Card Application Card Command
Interface

.....Pt. 3- PIV Client Application Programming
Interface

.....Pt. 4- The PIV Transitional Interfaces & Data
Model Specification

Special Pub 800-76-1 ...Biometric Data Specification for Personal
Identity Verification

Special Pub 800-78-2 ...Cryptographic Algorithms and Key Sizes for
Personal Identity Verification

Special Pub 800-79-1 ...Guidelines for the Accreditation of Personal
Identity Verification Card Issuers

Special Pub 800-85B-1 ..DRAFTPIV Data Model Test Guidelines

Special Pub 800-85A-2 ..PIV Card Application and Middleware Interface
Test Guidelines (SP 800-73-3 compliance)

Special Pub 800-96 PIV Card Reader Interoperability Guidelines

Special Pub 800-104A ...Scheme for PIV Visual Card Topography

V. Occupational and Safety Health Administration (OSHA):

29 CFR 1910.97 Nonionizing radiation

W. Section 508 of the Rehabilitation Act of 1973

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

X. Security Industry Association (SIA):

AG-01 Security CAD Symbols Standards

Y. Underwriters Laboratories, Inc. (UL):

1-05 Flexible Metal Conduit

5-04 Surface Metal Raceway and Fittings

6-07 Rigid Metal Conduit

44-05 Thermoset-Insulated Wires and Cables

50-07 Enclosures for Electrical Equipment

83-08 Thermoplastic-Insulated Wires and Cables

294-99 The Standard of Safety for Access Control

System Units

305-08 Standard for Panic Hardware

360-09 Liquid-Tight Flexible Steel Conduit

444-08 Safety Communications Cables

464-09 Audible Signal Appliances

467-07 Electrical Grounding and Bonding Equipment

486A-03 Wire Connectors and Soldering Lugs for Use with
Copper Conductors

486C-04 Splicing Wire Connectors

486D-05 Insulated Wire Connector Systems for
Underground Use or in Damp or Wet Locations

486E-00 Equipment Wiring Terminals for Use with
Aluminum and/or Copper Conductors

493-07 Thermoplastic-Insulated Underground Feeder and
Branch Circuit Cable

514A-04 Metallic Outlet Boxes

514B-04 Fittings for Cable and Conduit

51-05 Schedule 40 and 80 Rigid PVC Conduit

609-96 Local Burglar Alarm Units and Systems

634-07 Standards for Connectors with Burglar-Alarm
Systems

636-01 Standard for Holdup Alarm Units and Systems

639-97 Standard for Intrusion-Detection Units

651-05 Schedule 40 and 80 Rigid PVC Conduit

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- 651A-07 Type EB and A Rigid PVC Conduit and HDPE
Conduit
- 752-05 Standard for Bullet-Resisting Equipment
- 797-07 Electrical Metallic Tubing
- 827-08 Central Station Alarm Services
- 1037-09 Standard for Anti-theft Alarms and Devices
- 1635-10 Digital Alarm Communicator System Units
- 1076-95 Standards for Proprietary Burglar Alarm Units
and Systems
- 1242-06 Intermediate Metal Conduit
- 1479-03 Fire Tests of Through-Penetration Fire Stops
- 1981-03 Central Station Automation System
- 2058-05 High Security Electronic Locks
- 60950 Safety of Information Technology Equipment
- 60950-1 Information Technology Equipment - Safety -
Part 1: General Requirements
- Z. Uniform Federal Accessibility Standards (UFAS) 1984
- AA. United States Department of Commerce:
Special Pub 500-101 ...Care and Handling of Computer Magnetic Storage
Media

1.8 COORDINATION

- A. Coordinate arrangement, mounting, and support of electronic safety and security equipment:
1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 3. To allow right of way for piping and conduit installed at required slope.
 4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- C. Coordinate location of access panels and doors for electronic safety and security items that are behind finished surfaces or otherwise concealed.

1.9 MAINTENANCE & SERVICE

A. General Requirements

- 1. The Contractor shall provide all services required and equipment necessary to maintain the entire integrated electronic security system in an operational state as specified for a period of one (1) year after formal written acceptance of the system. The Contractor shall provide all necessary material required for performing scheduled adjustments or other non-scheduled work. Impacts on facility operations shall be minimized when performing scheduled adjustments or other non-scheduled work. See also General Project Requirements.

B. Description of Work

- 1. The adjustment and repair of the security system includes all software updates, panel firmware, and the following new items computers equipment, communications transmission equipment and data transmission media (DTM), local processors, security system sensors, physical access control equipment, facility interface, signal transmission equipment, and video equipment.

C. Personnel

- 1. Service personnel shall be certified in the maintenance and repair of the selected type of equipment and qualified to accomplish all work promptly and satisfactorily. The COR and A/E shall be advised in writing of the name of the designated service representative, and of any change in personnel. The COR and A/E shall be provided copies of system manufacturer certification for the designated service representative.

D. Schedule of Work

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

1. The work shall be performed during regular working hours, Monday through Friday, excluding federal holidays.

E. System Inspections

1. These inspections shall include:
 - a. The Contractor shall perform two (2) minor inspections at six (6) month intervals or more if required by the manufacturer, and two (2) major inspections offset equally between the minor inspections to effect quarterly inspection of alternating magnitude.
 - 1) Minor Inspections shall include visual checks and operational tests of all console equipment, peripheral equipment, local processors, sensors, electrical and mechanical controls, and adjustments on printers.
 - 2) Major Inspections shall include all work described for Minor Inspections and the following: clean all system equipment and local processors including interior and exterior surfaces; perform diagnostics on all equipment; operational tests of the CPU, switcher, peripheral equipment, recording devices, monitors, picture quality from each camera; check, walk test, and calibrate each sensor; run all system software diagnostics and correct all problems; and resolve any previous outstanding problems.

F. Emergency Service

1. The owner shall initiate service calls whenever the system is not functioning properly. The Contractor shall provide the Owner with an emergency service center telephone number. The emergency service center shall be staffed 24 hours a day 365 days a year. The Owner shall have sole authority for determining catastrophic and non-catastrophic system failures within parameters stated in General Project Requirements.
 - a. For catastrophic system failures, the Contractor shall provide same day four (4) hour service response with a defect correction time not to exceed eight (8) hours from [notification] [arrival on site]. Catastrophic system failures are defined as any system

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

failure that the Owner determines will place the facility(s) at increased risk.

- b. For non-catastrophic failures, the Contractor within eight (8) hours with a defect correction time not to exceed 24 hours from notification.

G. Operation

- 1. Performance of scheduled adjustments and repair shall verify operation of the system as demonstrated by the applicable portions of the performance verification test.

H. Records & Logs

- 1. The Contractor shall maintain records and logs of each task and organize cumulative records for each component and for the complete system chronologically. A continuous log shall be submitted for all devices. The log shall contain all initial settings, calibration, repair, and programming data. Complete logs shall be maintained and available for inspection on site, demonstrating planned and systematic adjustments and repairs have been accomplished for the system.

I. Work Request

- 1. The Contractor shall separately record each service call request, as received. The record shall include the serial number identifying the component involved, its location, date and time the call was received, specific nature of trouble, names of service personnel assigned to the task, instructions describing the action taken, the amount and nature of the materials used, and the date and time of commencement and completion. The Contractor shall deliver a record of the work performed within five (5) working days after the work was completed.

J. System Modifications

- 1. The Contractor shall make any recommendations for system modification in writing to the COR and A/E. No system modifications, including operating parameters and control settings, shall be made without prior written approval from the COR and A/E.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

Any modifications made to the system shall be incorporated into the operation and maintenance manuals and other documentation affected.

K. Software

1. The Contractor shall provide all software updates when approved by the Owner from the manufacturer during the installation and 12-month warranty period and verify operation of the system. These updates shall be accomplished in a timely manner, fully coordinated with the system operators, and incorporated into the operations and maintenance manuals and software documentation. There shall be at least one (1) scheduled update near the end of the first year's warranty period, at which time the Contractor shall install and validate the latest released version of the Manufacturer's software. All software changes shall be recorded in a log maintained in the unit control room. An electronic copy of the software update shall be maintained within the log. At a minimum, the contractor shall provide a description of the modification, when the modification occurred, and name and contact information of the individual performing the modification. The log shall be maintained in a white 3 ring binder and the cover marked "SOFTWARE CHANGE LOG".

1.10 MINIMUM REQUIREMENTS

- A. References to industry and trade association standards and codes are minimum installation requirement standards.
- B. Drawings and other specification sections shall govern in those instances where requirements are greater than those specified in the above standards.

1.11 DELIVERY, STORAGE, & HANDLING

- A. Equipment and materials shall be protected during shipment and storage against physical damage, dirt, moisture, cold and rain:
 1. During installation, enclosures, equipment, controls, controllers, circuit protective devices, and other like items, shall be protected against entry of foreign matter; and be vacuum cleaned both inside and outside before testing and operating and repainting if required.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

2. Damaged equipment shall be, as determined by the COR and A/E, placed in first class operating condition or be returned to the source of supply for repair or replacement.
 3. Painted surfaces shall be protected with factory installed removable heavy craft paper, sheet vinyl or equal.
 4. Damaged paint on equipment and materials shall be refinished with the same quality of paint and workmanship as used by the manufacturer so repaired areas are not obvious.
- B. Central Station, Workstations, and Controllers:
1. Store in temperature and humidity-controlled environment in original manufacturer's sealed containers. Maintain ambient temperature between 10 to 30 deg C (50 to 85 deg F), and not more than 80 percent relative humidity, non-condensing.
 2. Open each container; verify contents against packing list, and file copy of packing list, complete with container identification for inclusion in operation and maintenance data.
 3. Mark packing list with designations which have been assigned to materials and equipment for recording in the system labeling schedules generated by cable and asset management system.
 4. Save original manufacturer's containers and packing materials and deliver as directed under provisions covering extra materials.

1.12 PROJECT CONDITIONS

A. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Interior, Controlled Environment: System components, except central-station control unit, installed in temperature-controlled interior environments shall be rated for continuous operation in ambient conditions of 2 to 50 deg C (36 to 122 deg F) dry bulb and 20 to 90 percent relative humidity, non-condensing. NEMA 250, Type 1 enclosure.
2. Interior, Uncontrolled Environment: System components installed in non-temperature-controlled interior environments shall be rated for continuous operation in ambient conditions of -18 to 50 deg C (0 to

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

122 deg F) dry bulb and 20 to 90 percent relative humidity, non-condensing. NEMA 250, Type 4X enclosures.

3. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambient conditions of -34 to 50 deg C (-30 to 122 deg F) dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation where exposed to rain as specified in NEMA 250, winds up to 137 km/h (85 mph) and snow cover up to 610 mm (24 in) thick. NEMA 250, Type 4X enclosures.
4. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.
5. Corrosive Environment: For system components subjected to corrosive fumes, vapors, and wind-driven salt spray in coastal zones, provide NEMA 250, Type 4X enclosures.

B. Security Environment: Use vandal resistant enclosures in high-risk areas where equipment may be subject to damage.

C. Console: All console equipment shall, unless noted otherwise, be rated for continuous operation under ambient environmental conditions of 15.6 to 29.4 deg C (60 to 85 deg F) and a relative humidity of 20 to 80 percent.

1.13 EQUIPMENT AND MATERIALS

A. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, for which replacement parts shall be available.

B. When more than one unit of the same class of equipment is required, such units shall be the product of a single manufacturer.

C. Equipment Assemblies and Components:

1. Components of an assembled unit need not be products of the same manufacturer.

2. Manufacturers of equipment assemblies, which include components made by others, shall assume complete responsibility for the final assembled unit.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

3. Components shall be compatible with each other and with the total assembly for the intended service.
 4. Constituent parts which are similar shall be the product of a single manufacturer.
- D. Factory wiring shall be identified on the equipment being furnished and on all wiring diagrams.
- E. When Factory Testing Is Specified:
1. The Government shall have the option of witnessing factory tests. The contractor shall notify the VA through the COR and A/E a minimum of 15 working days prior to the manufacturers making the factory tests.
 2. Four copies of certified test reports containing all test data shall be furnished to the COR and A/E prior to final inspection and not more than 90 days after completion of the tests.
 3. When equipment fails to meet factory test and re-inspection is required, the contractor shall be liable for all additional expenses, including expenses of the Government.

1.14 ELECTRICAL POWER

- A. Electrical power of 120 Volts Alternating Current (VAC) shall be indicated on the Division 26 drawings. Additional locations requiring primary power required by the security system shall be shown as part of these contract documents. Primary power for the security system shall be configured to switch to emergency backup sources automatically if interrupted without degradation of any critical system function. Alarms shall not be generated as a result of power switching, however, an indication of power switching on (on-line source) shall be provided to the alarm monitor. The Security Contractor shall provide an interface (dry contact closure) between the PACS and the Uninterruptible Power Supply (UPS) system, so the UPS trouble signals, and main power fail appear on the PACS operator terminal as alarms.
- B. Failure of any on-line battery shall be detected and reported as a fault condition. Battery backed-up power supplies shall be provided sized for [8] <insert hours> hours of operation at actual connected load. Requirements for additional power or locations shall be included

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

with the contract to support equipment and systems offered. The following minimum requirements shall be provided for power sources and equipment.

1. Emergency Generator

- a. Report Printers: Unit Control Room
- b. Video Monitors: Unit Control Room
- c. Intercom Stations
- d. Radio System
- e. Lights: Unit Control Room, Equipment Rooms, & Security Offices
- f. Outlets: Security Outlets dedicated to security equipment racks or security enclosure assemblies.
- g. Security Device Power Supplies (DGP, VASS, Card Access, Lock Power, etc.) powered from the security closets or remotely: various locations
- h. Telephone/Radio Recording Equipment: Unit Control Room.
- i. VASS Camera Power Supplies: Security Closets
- j. VASS Pan/Tilt Units: Various Locations
- k. VASS Outdoor Housing Heaters and Blowers: Various Sites
- l. Intercom Master Control System
- m. Fiber Optic Receivers/Transmitters
- n. Security office Weapons Storage
- o. Outlets that charge handheld radios

2. Uninterruptible Power Supply (UPS) on Emergency Power

- a. The following 120VAC circuits shall be provided by others. The Security Contractor shall coordinate exact locations with the Electrical Contractor:
 - 1) Security System Monitors and Keyboards: Control Room
 - 2) CPU: Control Equipment Room
 - 3) Communications equipment: Control Equipment Room and various sites.
 - 4) VASS Matrix Switcher: Control Equipment Room
 - 5) VASS: Control Equipment Room
 - 6) Digital Video Recorders, encoders & decoders: Control Room
 - 7) All equipment Room racked equipment.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

8) Network switches

1.15 TRANSIENT VOLTAGE SUPPRESSION, POWER SURGE SUPPLESION, & GROUNDING

- A. Transient Voltage Surge Suppression: All cables and conductors extending beyond building façade, except fiber optic cables, which serve as communication, control, or signal lines shall be protected against Transient Voltage surges and have Transient Voltage Surge Suppression (TVSS) protection. The TVSS device shall be UL listed in accordance with Standard TIA 497B installed at each end. Lighting and surge suppression shall be a multi-strike variety and include a fault indicator. Protection shall be furnished at the equipment and additional triple solid state surge protectors rated for the application on each wire line circuit shall be installed within 914.4 mm (3 ft) of the building cable entrance. Fuses shall not be used for surge protection. The inputs and outputs shall be tested in both normal mode and common mode to verify there is no interference.
1. A 10-microsecond rise time by 1000 microsecond pulse width waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.
 2. An 8-microsecond rise time by 20-microsecond pulse width waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.
 3. Maximum series current: 2 AMPS. Provide units manufactured by Advanced Protection Technologies, model # TE/FA 10B or TE/FA 20B.
 4. Operating Temperature and Humidity: -40 to 85 deg C (-40 to 185 deg F), 0 to 95 percent relative humidity.
- B. Grounding and Surge Suppression
1. The Security Contractor shall provide grounding and surge suppression to stabilize the voltage under normal operating conditions. To ensure the operation of over current devices, such as fuses, circuit breakers, and relays, underground-fault conditions.
 2. Security Contractor shall engineer and provide proper grounding and surge suppression as required by local jurisdiction and prevailing codes and standards referenced in this document.
 3. Principal grounding components and features. Include main grounding buses and grounding and bonding connections to service equipment.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

4. Details of interconnection with other grounding systems. The lightning protection system shall be provided by the Security Contractor.
5. Locations and sizes of grounding conductors and grounding buses in electrical, data, and communication equipment rooms and closets.
6. AC power receptacles are not to be used as a ground reference point.
7. Any cable that is shielded shall require a ground in accordance with the best practices of the trade and manufactures installation instructions.
8. Protection should be provided at both ends of cabling.

1.16 COMPONENT ENCLOSURES

A. Construction of Enclosures

1. Consoles, power supply enclosures, detector control and terminal cabinets, control units, wiring gutters, and other component housings, collectively referred to as enclosures, shall be so formed and assembled as to be sturdy and rigid.
2. Thickness of metal in-cast and sheet metal enclosures of all types shall not be less than those in Tables I and II, UL 611. Sheet steel used in fabrication of enclosures shall be not less than 14 gauge. Consoles shall be 16-gauge.
3. Doors and covers shall be flanged. Enclosures shall not have pre-punched knockouts. Where doors are mounted on hinges with exposed pins, the hinges shall be of the tight pin type, or the ends of hinge pins shall be tack welded to prevent removal. Doors having a latch edge length of less than 609.6 mm (24 in) shall be provided with a single construction core. Where the latch edge of a hinged door is more than 609.6 mm (24 in) or more in length, the door shall be provided with a three-point latching device with construction core; or alternatively with two, one located near each end.
4. Any ventilator openings in enclosures and cabinets shall conform to the requirements of UL 611. Unless otherwise indicated, sheet metal enclosures shall be designed for wall mounting with tip holes slotted. Mounting holes shall be in positions that remain

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- accessible when all major operating components are in place and the door is open but shall be in accessible when the door is closed.
5. Covers of pull and junction boxes provided to facilitate initial installation of the system shall be held in place by tamper proof Torx Center post security screws. Stenciled or painted labels shall be affixed to such boxes indicating they contain no connections. These labels shall not indicate the box is part of the Electronic Security System (ESS).
- B. Consoles & Equipment Racks: All consoles and vertical equipment racks shall include a forced air-cooling system to be provided by others.
1. Vertical Equipment Racks:
- a. The forced air blowers shall be installed in the vented top of each cabinet and shall not reduce usable rack space.
 - b. The forced air fan shall consist of one fan rated at 105 CFM per rack bay and noise level shall not exceed 55 decibels.
 - c. d. Vertical equipment racks are to be provided with full sized clear plastic locking doors and vented top panels as shown on contract drawings.
2. Console racks:
- a. Forced air fans shall be installed in the top rear of each console bay. The forced air fan shall consist of one fan rated at 105 CFM mounted to a 133mm vented blank panel the noise level of each fan shall not exceed 55 decibels. The fans shall be installed so air is pulled from the bottom of the rack or cabinet and exhausted out the top.
 - b. Console racks are to be provided with flush mounted hinged rear doors with recessed locking latch on the bottom and middle sections of the consoles. Provide code access to support wiring for devices located on the work surfaces.
- C. Tamper Provisions and Tamper Switches:
1. Enclosures, cabinets, housings, boxes and fittings or every product description having hinged doors or removable covers, and which contain circuits, or the integrated security system and its power

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- supplies shall be provided with cover operated, corrosion-resistant tamper switches.
2. Tamper switches shall be arranged to initiate an alarm signal that will report to the monitoring station when the door or cover is moved. Tamper switches shall be mechanically mounted to maximize the defeat time when enclosure covers are opened or removed. It shall take longer than 1 second to depress or defeat the tamper switch after opening or removing the cover. The enclosure and tamper switch shall function together in such a manner as to prohibit direct line of sight to any internal component before the switch activates.
 3. Tamper switches shall be inaccessible until the switch is activated. Have mounting hardware concealed so the location of the switch cannot be observed from the exterior of the enclosure. Be connected to circuits which are under electrical supervision at all times, irrespective of the protection mode in which the circuit is operating. Be spring-loaded and held in the closed position by the door or cover and be wired so they break the circuit when the door cover is disturbed. Tamper circuits shall be adjustable type screw sets and shall be adjusted by the contractor to eliminate nuisance alarms associated with incorrectly mounted tamper device shall annunciate prior to the enclosure door opening (within 1/4 "tolerance. The tamper device or its components shall not be visible or accessible with common tools to bypass when the enclosure is in the secured mode.
 4. The single gang junction boxes for the portrait alarming and pull boxes with less than 102 square mm will not require tamper switches.
 5. All enclosures over 305 square mm shall be hinged with an enclosure lock.
 6. Control Enclosures: Maintenance/Safety switches on control enclosures, which must be opened to make routing maintenance adjustments to the system and to service the power supplies, shall be push/pull-set automatic reset type.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

28 05 00 - 49

Common Work Results for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

7. Provide one (1) enclosure tamper switch for each 609 linear mm of enclosure lock side opening evenly spaced.
8. All security screws shall be Torx-Post Security Screws.
9. The contractor shall provide the owner with two (2) torx-post screwdrivers.

1.17 ELECTRONIC COMPONENTS

- A. All electronic components of the system shall be of the solid-state type, mounted on printed circuit boards conforming to UL 796. Boards shall be plug-in, quick-disconnect type. Circuitry shall not be so densely placed as to impede maintenance. All power-dissipating components shall incorporate safety margins of not less than 25 percent with respect to dissipation ratings, maximum voltages, and current-carrying capacity.

1.18 SUBSTITUTE MATERIALS & EQUIPMENT

- A. Where variations from the contract requirements are requested in accordance with the GENERAL CONDITIONS and Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, the connecting work and related components shall include, but not be limited to additions or changes to branch circuits, circuit protective devices, conduits, wire, feeders, controls, panels and installation methods.
- B. In addition to this Section the Security Contractor shall also reference Section II, Products and associated divisions. The COR and A/E shall have final authority on the authorization or refusal of substitutions. If there are no proposed substitutions, a statement in writing from the Contractor shall be submitted to the COR and A/E stating same. In the preparation of a list of substitutions, the following information shall be included, as a minimum:
 1. Identity of the material or devices specified for which there is a proposed substitution.
 2. Description of the segment of the specification where the material or devices are referenced.
 3. Identity of the proposed substitute by manufacturer, brand name, catalog or model number and the manufacturer's product name.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

4. A technical statement of all operational characteristic expressing equivalence to items to be substituted and comparison, feature-by-feature, between specification requirements and the material or devices called for in the specification, and Price differential.
- C. Materials Not Listed: Furnish all necessary hardware, software, programming materials, and supporting equipment required to place the specified major subsystems in full operation. Note that some supporting equipment, materials, and hardware may not be described herein. Depending on the manufacturers selected by the COTR, some equipment, materials and hardware may not be contained in either the Contract Documents or these written specifications but are required by the manufacturer for complete operation according to the intent of the design and these specifications. In such cases, the COR and A/E shall be given the opportunity to approve the additional equipment, hardware and materials that shall be fully identified in the bid and in the equipment list submittal. The COR and A/E shall be consulted in the event there is any question about which supporting equipment, materials, or hardware is intended to be included.
- D. Response to Specification: The Contractor shall submit a point-by-point statement of compliance with each paragraph of the security specification. The statement of compliance shall list each paragraph by number and indicate "COMPLY" opposite the number for each paragraph where the Contractor fully complies with the specification. Where the proposed system cannot meet the requirements of the paragraph, and does not offer an equivalent solution, the offers shall indicate "DOES NOT COMPLY" opposite the paragraph number. Where the proposed system does not comply with the paragraph as written, but the bidder feels it will accomplish the intent of the paragraph in a manner different from that described, the offers shall indicate "COMPARABLE". The offers shall include a statement fully describing the "comparable" method of satisfying the requirement. Where a full and concise description is not provided, the offered system shall be considered as not complying with the specification. Any submission that does not include a point-by-point statement of compliance, as described above, shall be

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

disqualified. Submittals for products shall be in precise order with the product section of the specification. Submittals not in proper sequence will be rejected.

1.19 LIKE ITEMS

- A. Where two or more items of equipment performing the same function are required, they shall be exact duplicates produced by one manufacturer. All equipment provided shall be complete, new, and free of any defects.

1.20 WARRANTY

- A. The Contractor shall, as a condition precedent to the final payment, execute a written guarantee (warranty) to the COTR certifying all contract requirements have been completed according to the final specifications. Contract drawings and the warranty of all materials and equipment furnished under this contract are to remain in satisfactory operating condition (ordinary wear and tear, abuse and causes beyond his control for this work accepted) for one (1) year from the date the Contractor received written notification of final acceptance from the COTR. Demonstration and training shall be performed prior to system acceptance. All defects or damages due to faulty materials or workmanship shall be repaired or replaced without delay, to the COTR's satisfaction, and at the Contractor's expense. The Contractor shall provide quarterly inspections during the warranty period. The contractor shall provide written documentation to the COTR on conditions and findings of the system and device(s). In addition, the contractor shall provide written documentation of test results and stating what was done to correct any deficiencies. The first inspection shall occur 90 calendar days after the acceptance date. The last inspection shall occur 30 calendar days prior to the end of the warranty. The warranty period shall be extended until the last inspection and associated corrective actions are complete. When equipment and labor covered by the Contractor's warranty, or by a manufacturer's warranty, have been replaced or restored because of its failure during the warranty period, the warranty period for the replaced or repaired equipment or restored work shall be reinstated for

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

a period equal to the original warranty period, and commencing with the date of completion of the replacement or restoration work. In the event any manufacturer customarily provides a warranty period greater than one (1) year, the Contractor's warranty shall be for the same duration for that component.

1.22 SINGULAR NUMBER

Where any device or part of equipment is referred to in these specifications in the singular number (e.g., "the switch"), this reference shall be deemed to apply to as many such devices as are required to complete the installation as shown on the drawings.

PART 2 - PRODUCTS

2.1 EQUIPMENT AND MATERIALS

- A. All equipment associated within the Security Control Room, Security Console and Security Equipment Room shall be UL 827, UL 1981, and UL 60950 compliant and rated for continuous operation. Environmental conditions (i.e., temperature, humidity, wind, and seismic activity) shall be taken under consideration at each facility and site location prior to installation of the equipment.
- B. All equipment shall operate on 120 or 240 volts alternating current (VAC); 50 Hz or 60 Hz AC power system unless documented otherwise in subsequent sections listed within this specification. All equipment shall have a back-up source of power that will provide a minimum of [8] <insert hours> hours of run time in the event of a loss of primary power to the facility.
- C. The system shall be designed, installed, and programmed in a manner that will allow for ease of operation, programming, servicing, maintenance, testing, and upgrading of the system.
- D. All equipment and materials for the system will be compatible to ensure correct operation.

2.2 EQUIPMENT ITEMS

- A. The Security Management System shall provide full interface with all components of the security subsystem as follows:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

1. Shall allow for communication between the Physical Access Control System and Database Management and all subordinate work and monitoring stations, enrollment centers for badging and biometric devices as part of the PACS, local annunciation centers, the electronic Security Management System (SMS), and all other VA redundant or backup command center or other workstations locations.
2. Shall provide automatic continuous communication with all systems that are monitored by the SMS and shall automatically annunciate any communication failures or system alarms to the SMS operator providing identification of the system, nature of the alarm, and location of the alarm.
3. Controlling devices shall be utilized to interface the SMS with all field devices.

B. Wires and Cables:

1. Shall meet or exceed the manufactures recommendation for power and signals.
2. Shall be carried in an enclosed conduit system, utilizing electromagnetic tubing (EMT) to include the equivalent in flexible metal, rigid galvanized steel (RGS) to include the equivalent of liquid tight, polyvinylchloride (PVC) schedule 40 or 80.
3. All conduits will be sized and installed per the NEC. All security system signal and power cables that traverse or originate in a high security office space will contained in either EMT or RGS conduit.
4. All conduit, pull boxes, and junction boxes shall be marked with colored permanent tape or paint that will allow it to be distinguished from all other infrastructure conduit.
5. Conduit fills shall not exceed 50 percent unless otherwise documented.
6. A pull string shall be pulled along and provided with signal and power cables to assist in future installations.
7. At all locations where there is a wall penetration or core drilling is conducted to allow for conduit to be installed, fire stopping materials shall be applied to that area.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

8. High voltage and signal cables shall not share the same conduit and shall be kept separate up to the point of connection. High voltage for the security subsystems shall be any cable or sets of cables carrying 30 VDC/VAC or higher.
9. For all equipment that is carrying digital data between the Security Control Room, Security Equipment Room, Security Console, or at a remote monitoring station, it shall not be less than 20 AWG and stranded copper wire for each conductor. The cable or each individual conductor within the cable shall have a shield that provides 100% coverage. Cables with a single overall shield shall have a tinned copper shield drain wire.

2.3 TRANSIENT VOLTAGE SURGE SUPPRESSION DEVICES (TVSS) AND SURGE SUPPRESSION

A. Transient Voltage Surge Suppression

1. All cables and conductors extending beyond building perimeter, except fiber optic cables, which serve as communication, control, or signal lines shall be protected against Transient Voltage surges and have Transient Voltage surge suppression protection (TVSS) UL listed in accordance with Standard 497B installed at each end. Lighting and surge suppression shall be a multi-strike variety and include a fault indicator. Protection shall be furnished at the equipment and additional triple solid state surge protectors rated for the application on each wire line circuit shall be installed within 915 mm (36 in) of the building cable entrance. Fuses shall not be used for surge protection. The inputs and outputs shall be tested in both normal mode and common mode using the following waveforms:
 - a. A 10-microsecond rise time by 1000 microsecond pulse width waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.
 - b. An 8-microsecond rise time by 20-microsecond pulse width waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.
 - c. Maximum series current: 2 AMPS. Provide units manufactured by Advanced Protection Technologies, model # TE/FA 10B or TE/FA 20B or approved equivalent.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- d. Operating Temperature and Humidity: -40 to + 85 deg C (-40 to 185 deg F), and 0 to 95 percent relative humidity, non-condensing.

B. Physical Access Control Systems

1. Suppressors shall be installed on AC power at the point of service and shall meet the following criteria:
 - a. UL1449 2nd Edition, 2007, listed
 - b. UL1449 S.V.R. of 400 Volts or lower
 - c. Status Indicator Light(s)
 - d. Minimum Surge Current Capacity: 40,000 Amps (8 x 20 µsec)
 - e. Maximum Continuous Current: 15 Amps
 - f. MCOV: 125 VAC
 - g. Service Voltage: 110-120 VAC
2. Suppressors shall be installed on the Low Voltage circuit at both the point of entrance and exit of the building. Suppressors shall meet the following criteria:
 - a. UL 497B
 - b. Minimum Surge Current Capacity: 2,000 Amps per pair
 - c. Maximum Continuous Current : 5 Amps
 - d. MCOV : 33 Volts
 - e. Service Voltage: 24Volts
3. Suppressors shall be installed on the communication circuit between the access controller and card reader at both the entrance and exit of the building. Suppressors shall meet the following criteria:
 - a. Conforms with UL497B standards (where applicable)
 - b. Clamp level for 12 and 24V power: 18VDC / 38VDC
 - c. Clamp level for Data/LED: 6.8VDC
 - d. Service Voltage for Power: 12VDC/24VDC
 - e. Service Voltage for Data/LED: <5VDC
 - f. Clamp level - PoE Access Power: 72V
 - g. Clamp level - PoE Access Data: 7.9V
 - h. Service Voltage - PoE Access: 48VAC - 54VAC
 - i. Service Voltage - PoE Data: <5VDC

C. Video Surveillance System

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

1. Protectors shall be installed on coaxial cable systems on points of entry and exit from separate buildings. Suppressors shall be installed at each exterior camera location and include protection for 12 and/or 24-volt power, data signal and motor controls (for Pan, Tilt and Zoom systems). SPDs shall protect all modes herein mentioned and contain all modes in a single unit system. Protection for all systems mentioned above shall be incorporated at the head end equipment. Additionally a minimum 450VA battery backup shall be used to protect the DVR or VCR and monitor. Protectors shall meet the following criteria:

- a. Head-End Power

- 1) UL 1778, Cul (Battery Back Up)
- 2) Minimum Surge Current Capacity: 65,000 Amps (8x20µsec)
- 3) Minimum of two (2) NEMA 5-15R Receptacles (one (1) AC power only, one (1) with UPS)
- 4) All modes protected (L-N, L-G, N-G)
- 5) EMI/RFI Filtering
- 6) Maximum Continuous Current: 12 Amps

- b. Camera Power

- 1) Minimum Surge Current Capacity: 1,000 Amps (8X20µsec); 240 Amps for IP Video/PoE cameras
- 2) Screw Terminal Connection
- 3) All protection modes L-G (all Lines)
- 4) MCOV <40VAC

- c. Video And Data

- 1) Surge Current Capacity 1,000 Amps per conductor
- 2) "BNC" Connection (Coax)
- 3) Protection modes: L-G (Data), Center Pin-G, Shield-G (Coax)
- 4) Band Pass 0-2GHz
- 5) Insertion Loss <0.3dB

- D. Grounding and Surge Suppression

1. The Security Contractor shall provide grounding and surge suppression to stabilize the voltage under normal operating conditions. This is to ensure the operation of over current

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

28 05 00 - 57

Common Work Results for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

devices, such as fuses, circuit breakers, and relays, underground-fault conditions.

2. The Contractor shall engineer, provide, and install proper grounding and surge suppression as required by local jurisdiction and prevailing codes and standards, referenced in this document.
3. Principal grounding components and features shall include main grounding buses, grounding, and bonding connections to service equipment.
4. The Contractor shall provide detail drawings of interconnection with other grounding systems including lightning protection systems.
5. The Contractor shall provide details of locations and sizes of grounding conductors and grounding buses in electrical, data, and communication equipment rooms and closets.
6. AC power receptacles are not to be used as a ground reference point.
7. Any cable that is shielded shall require a ground in accordance with applicable codes, the best practices of the trade, and all manufactures' installation instructions.

E. 120 VAC Surge Suppression

1. Continuous Current: Unlimited (parallel connection)
2. Max Surge Current: 13,500 Amps
3. Protection Modes: L - N, L - G, N - G
4. Warranty: Ten Year Limited Warranty
5. Dimension: 73.7 x 41.1 x 52.1 mm (2.90 x 1.62 x 2.05 in)
6. Weight: 2.88 g (0.18 lbs.)
7. Housing: ABS

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRONIC SAFETY AND SECURITY INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electronic safety and security equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- E. Right of Way: Give to piping systems installed at a required slope.
- F. Equipment location shall be as close as practical to locations shown on the drawings.
- G. Inaccessible Equipment:
 - 1. Where the Government determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, the equipment shall be removed and reinstalled as directed at no additional cost to the Government.
 - 2. "Conveniently accessible" is defined as being capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as, but not limited to, motors, pumps, belt guards, transformers, piping, ductwork, conduit and raceways.

3.2 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electronic safety and security installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section 07 84 00 "Firestopping."

3.3 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 28 08 00 - COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to section 28 08 00 - COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY SYSTEMS and related sections for contractor responsibilities for system commissioning.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

3.4 DEMONSTRATION AND TRAINING

- A. Training shall be provided in accordance with Article, INSTRUCTIONS, of Section 01 00 00, GENERAL REQUIREMENTS.
- B. Training shall be provided for the particular equipment or system as required in each associated specification.
- C. A training schedule shall be developed and submitted by the contractor and approved by the COR and A/E at least 30 days prior to the planned training.
- D. Provide services of manufacturer's technical representative for <insert hours> hours to instruct VA personnel in operation and maintenance of units.
- E. Submit training plans and instructor qualifications in accordance with the requirements of Section 28 08 00 - COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY SYSTEMS.

3.5 WORK PERFORMANCE

- A. Job site safety and worker safety is the responsibility of the contractor.
- B. For work on existing stations, arrange, phase and perform work to assure electronic safety and security service for other buildings at all times. Refer to Article OPERATIONS AND STORAGE AREAS under Section 01 00 00, GENERAL REQUIREMENTS.
- C. New work shall be installed and connected to existing work neatly and carefully. Disturbed or damaged work shall be replaced or repaired to its prior conditions, as required by Section 01 00 00, GENERAL REQUIREMENTS.
- D. Coordinate location of equipment and conduit with other trades to minimize interferences. See the GENERAL CONDITIONS.

3.6 SYSTEM PROGRAMMING

- A. General Programming Requirements
 - 1. This following section shall be used by the contractor to identify the anticipated level of effort (LOE) required setup, program, and configure the Electronic Security System (ESS). The contractor shall be responsible for providing all setup, configuration, and

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

programming to include data entry for the Security Management System (SMS) and subsystems [(e.g., video matrix switch, intercoms, digital video recorders, intrusion devices, including integration of subsystems to the SMS (e.g., camera call up, time synchronization, intercoms)]. System programming for existing or new SMS servers shall not be conducted at the project site.

B. Level of Effort for Programming

1. The Contractor shall perform and complete system programming (including all data entry) at an offsite location using the Contractor's own copy of the SMS software. The Contractor's copy of the SMS software shall be of the Owners current version. Once system programming has been completed, the Contractor shall deliver the data to the COR and A/E on data entry forms and an approved electronic medium, utilizing data from the contract documents. The completed forms shall be delivered to the COR and A/E for review and approval at least 90 calendar days prior to the scheduled date the Contractor requires it. The Contractor shall not upload system programming until the COR and A/E has provided written approval. The Contractor is responsible for backing up the system prior to uploading new programming data. Additional programming requirements are provided as follows:

- a. Programming for New SMS Server: The contractor shall provide all other system related programming. The contractor will be responsible for uploading personnel information (e.g., ID Cards backgrounds, names, access privileges, personnel photos, access schedules, personnel groupings) along with coordinating with COR and A/E for device configurations, standards, and groupings. VA shall provide database to support Contractor's data entry tasks. The contractor shall anticipate a weekly coordination meeting and working with COR and A/E to ensure data uploading is performed without incident of loss of function or data loss.
- b. Programming for Existing SMS Servers: The contractor shall perform all related system programming except for personnel data as noted. The contractor will not be responsible for uploading

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

personnel information (e.g., ID Cards backgrounds, names, access privileges, access schedules, personnel groupings). The contractor shall anticipate a weekly coordination meeting and working alongside of COR and A/E to ensure data uploading is performed without incident of loss of function or data loss. System programming for SMS servers shall be performed by using the Contractor's own server and software. These servers shall not be connected to existing devices or systems at any time.

2. The Contractor shall identify and request from the COR and A/E, any additional data needed to provide a complete and operational system as described in the contract documents.
3. Contractor and COR and A/E coordination on programming requires a high level of coordination to ensure programming is performed in accordance with VA requirements and programming uploads do not disrupt existing systems functionality. The contractor shall anticipate a minimum a weekly coordination meeting. Contractor shall ensure data uploading is performed without incident of loss of function or data loss. The following Level of Effort Chart is provided to communicate the expected level of effort required by contractors on VA ESS projects. Calculations to determine actual levels of effort shall be confirmed by the contractor before project award.

Description of Tasks							
Descr iptio n of Syste ms	Develop System Loading Sheets	Coordina tion	Initial Set-up Configur ation	Graphic Maps	Syst em Prog ramm ing	Final Checks	Level of Effort (Typical Tasks)

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

SMS Setup & Configuration	e.g., program monitoring stations, programming networks, interconnections between CCTV, intercoms, time synchronization	e.g., retrieve IP addresses, naming conventions, standard event descriptions, programming template s, coordinate special system needs	e.g., Load system Operating System and Application software, general system configurations	e.g., develop naming conventions, develop file folders, confirming accuracy of AutoCAD Floor Plans, convert file into jpeg file	e.g., program monitoring stations, programming networks, interconnections between CCTV, intercoms, time synchronization	e.g., check all system diagnostics (e.g., client s, panels)	Load and set-up 4-6 CDs and configure servers (to configure Loading and Configuring software Administrative account, audit log, Keystrokes, mouse clicks, multi-screen configuration

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
 Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

Electronic Entry Control Systems	e.g., setup of device, door groups & schedules, REX, Locks, link graphics	e.g., confirming device configurations, naming conventions, event description and narratives	e.g., enter data from loading sheets; configure components, link events, cameras, and graphics		e.g., , setup of device, door groups & schedules, REX, Locks, link graphics	e.g., performing entry testing to confirm correct setup and configuration	e.g., creating a door, door configuration, adding request to exit, door monitors and relays, door timers, door related events (e.g., access, access denied, forced open, held open), linkages, controlled areas, advanced door monitoring, time zones, sequence of operations

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

Intru sion Dete ction Syste ms	e.g., enter door groups & schedule s, link devices - REX, lock, & graphics	e.g., confirmi ng device configur ations, naming conventi ons, event descript ion and narrativ es	e.g., enter data from loading sheets; configur e componen ts, link events, cameras, and graphics		e.g., , ente r door grou ps & sche dule s, link devi ces - REX, lock , & grap hics	e.g., walk test, device positi on, and maskin g	e.g., setting up monitoring and control points (e.g., motion sensors, glassbreaks, vibration sensor, strobes, sounders) creating intrusion zones, creating arm/disarm panel, timed sequences, time zones, icon placements on graphic maps, clearance levels, events (e.g., armed, disarmed, zone violation, device alarm activations), LCD reader messages,

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
 Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

CCTV Systems	e.g., programming call-ups recording	e.g., confirming device configurations, naming conventions	e.g., enter data from loading sheets; camera naming convention, sequence s, configure components)		e.g., programming call-ups recording	e.g., confirm area of coverage, call-up per event generated and recording rates	e.g., setting up cameras points, recording ratios (e.g., normal, alarm event) timed recording, linkages, maps placements, call-ups
Intercoms Systems	e.g., programming events & call-ups	e.g., confirming device configurations, naming conventions, event description and narratives	e.g., enter data from loading sheets; configure components, link events, cameras, and graphics		e.g., programming events & call-ups	e.g., confirm operation, SMS event generation and camera call-up	e.g., setup linkages, events for activations, device troubles, land devices on graphic maps

Contract No. 36C26319D0044
 Station Project No. 437-21-210
 Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

Console Monitoring Components	N/A	per monitor	per monitor	per graphic map	N/A	per monitor	N/A
Note: Programming tasks are supported through the contractor's development of the Technical Data Package Submittals.							

Table 1 Contractor Level of Effort

3.7 TESTING AND ACCEPTANCE

A. Performance Requirements

1. General:

- a. The Contractor shall perform contract field, performance verification, and endurance testing and make adjustments of the completed security system when permitted. The Contractor shall provide all personnel, equipment, instrumentation, and supplies necessary to perform all testing. Written notification of planned testing shall be given to the COR and A/E at least 60 calendar days prior to the test and after the Contractor has received written approval of the specific test procedures.
- b. The COR shall witness all testing and system adjustments during testing. Written permission shall be obtained from the COR and A/E before proceeding with the next phase of testing. Original copies of all data produced during performance verification and endurance testing shall be turned over to the COR and A/E at the conclusion of each phase of testing and prior to COR and A/E approval of the test.

2. Test Procedures and Reports: The test procedures, compliant w/ VA standard test procedures, shall explain in detail, step-by-step actions and expected results demonstrating compliance with the requirements of the specification. The test reports shall be used to document results of the tests. The reports shall be delivered to the COR and A/E within seven (7) calendar days after completion of each test.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

E. Contractor's Field Testing (CFT)

1. The Contractor shall calibrate and test all equipment, verify DTM operation, place the integrated system in service, and test the integrated system. Ground rods installed by this Contractor within the base of camera poles shall be tested as specified in IEEE STD 142. The Contractor shall test all security systems and equipment and provide written proof of a 100% operational system before a date is established for the system acceptance test. Documentation package for CFT shall include completed (fully annotated details of test details) for each device and system tested, and annotated loading sheets documenting complete testing to COR and A/E approval. CFT test documentation package shall conform to submittal requirements outlined in this Section. The Contractor's field-testing procedures shall be identical to the COR and A/E acceptance testing procedures. The Contractor shall provide the COR and A/E with a written listing of all equipment and software indicating all equipment and components have been tested and passed. The Contractor shall deliver a written report to the A/E and COR stating the installed complete system has been calibrated, tested, and is ready to begin performance verification testing; describing the results of the functional tests, diagnostics, and calibrations; and the report shall also include a copy of the approved acceptance test procedure. Performance verification testing shall not take place until written notice by contractor is received certifying that a contractor's field test was successful.

F. Performance Verification Test (PVT)

1. Test team:
 - a. After the system has been pretested and the Contractor has submitted the pretest results and certification to the COR and A/E, then the Contractor shall schedule an acceptance test to date and give the COR and A/E written, notice as described herein, prior to the date the acceptance test is expected to begin. The system shall be tested in the presence of a Government Representative, an OEM certified representative,

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

representative of the Contractor and other approved by the COR and A/E. The system shall be tested utilizing the approved test equipment to certify proof of performance, FCC, UL and Emergency Service compliance. The test shall verify that the total system meets all the requirements of this specification. The notification of the acceptance test shall include the expected length (in time) of the test.

2. The Contractor shall demonstrate the completed Physical Access Control System PACS complies with the contract requirements. In addition, the Contractor shall provide written certification that the system is 100% operational prior to establishing a date for starting PVT. Using approved test procedures, all physical and functional requirements of the project shall be demonstrated and shown. The PVT will be stopped and aborted as soon as 10 technical deficiencies are found requiring correction. The Contractor shall be responsible for all travel and lodging expenses incurred for out-of-town personnel required to be present for resumption of the PVT. If the acceptance test is aborted, the re-test will commence from the beginning with a retest of components previously tested and accepted.
3. The PVT, as specified, shall not begin until receipt of written certification that the Contractors Field Testing was successful. This shall include certification of successful completion of testing as specified in paragraph "Contractor's Field Testing", and upon successful completion of testing at any time when the system fails to perform as specified. Upon termination of testing by the COR and A/E or Contractor, the Contractor shall commence an assessment period as described for Endurance Testing Phase II.
4. Upon successful completion of the acceptance test, the Contractor shall deliver test reports and other documentation, as specified, to the COR and A/E prior to commencing the endurance test.
5. Additional Components of the PVT shall include:
 - a. System Inventory

- 1) All Device equipment

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- 2) All Software
- 3) All Logon and Passwords
- 4) All Cabling System Matrices
- 5) All Cable Testing Documents
- 6) All System and Cabinet Keys

b. Inspection

- 1) Contractor shall record an inspection punch list noting all system deficiencies. The contractor shall prepare an inspection punch list format for COR and A/E approval.
- 2) As a minimum the punch list shall include a listing of punch list items, punch list item location, description of item problem, date noted, date corrected, and details of how item was corrected.

6. Partial PVT - At the discretion of COR and A/E, the Performance Verification Test may be performed in part should a 100% compliant CFT be performed. In the event that a partial PVT will be performed instead of a complete PVT; the partial PVT shall be performed by testing 10% of the system. The contractor shall perform a test of each procedure on select devices or equipment.

G. Endurance Test

1. The Contractor shall demonstrate the specified probability of detection and false alarm rate requirements of the completed system. The endurance test shall be conducted in phases as specified below. The endurance test shall not be started until the COR and A/E notifies the Contractor, in writing, that the performance verification test is satisfactorily completed, training as specified has been completed, and correction of all outstanding deficiencies has been satisfactorily completed. VA shall operate the system 24 hours per day, including weekends and holidays, during Phase I and Phase III endurance testing. VA will maintain a log of all system deficiencies. The COR and A/E may terminate testing at any time the system fails to perform as specified. Upon termination of testing, the Contractor shall commence an assessment period as described for Phase II. During the last day of the test, the Contractor shall

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

28 05 00 - 70

Common Work Results for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- verify the appropriate operation of the system. Upon successful completion of the endurance test, the Contractor shall deliver test reports and other documentation as specified to the COR and A/E prior to acceptance of the system.
2. Phase I (Testing): The test shall be conducted 24 hours per day for 15 consecutive calendar days, including holidays, and the system shall operate as specified. The Contractor shall make no repairs during this phase of testing unless authorized in writing by the COR and A/E. If the system experiences no failures, the Contractor may proceed directly to Phase III testing after receiving written permission from the COR and A/E.
3. Phase II (Assessment):
- a. After the conclusion of Phase I, the Contractor shall identify all failures, determine causes of all failures, repair all failures, and deliver a written report to the COR and A/E. The report shall explain in detail the nature of each failure, corrective action taken, results of tests performed, and recommend the point at which testing should be resumed.
 - b. After delivering the written report, the Contractor shall convene a test review meeting at the job site to present the results and recommendations to the COR and A/E. The meeting shall not be scheduled earlier than five (5) business days after the COR and A/E receives the report. As part of this test review meeting, the Contractor shall demonstrate all failures have been corrected by performing appropriate portions of the performance verification test. Based on the Contractor's report and the test review meeting, the COR and A/E will provide a written determine of either the restart date or require Phase I be repeated.
4. Phase III (Testing): The test shall be conducted 24 hours per day for 15 consecutive calendar days, including holidays, and the system shall operate as specified. The Contractor shall make no repairs during this phase of testing unless authorized in writing by the COTR.

5. Phase IV (Assessment):

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

01/16/2024

28 05 00 - 71

Common Work Results for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

1. After the conclusion of Phase III, the Contractor shall identify all failures, determine causes of all failures, repair all failures, and deliver a written report to the COTR. The report shall explain in detail the nature of each failure, corrective action taken, results of tests performed, and recommend the point at which testing should be resumed.
2. After delivering the written report, the Contractor shall convene a test review meeting at the job site to present the results and recommendations to the COTR. The meeting shall not be scheduled earlier than five (5) business days after receipt of the report by the COTR. As a part of this test review meeting, the Contractor shall demonstrate that all failures have been corrected by repeating appropriate portions for the performance verification test. Based on the review meeting the test should not be scheduled earlier than five (5) business days after the COR and A/E receives the report. As a part of this test review meeting, the Contractor shall demonstrate all failures have been corrected by repeating appropriate portions of the performance verification test. Based on the Contractor's report and the test review meeting, the COR and A/E will provide a written determine of either the restart date or require Phase III be repeated. After the conclusion of any re-testing which the COR and A/E may require, the Phase IV assessment shall be repeated as if Phase III had just been completed.

H. Exclusions

1. The Contractor will not be held responsible for failures in system performance resulting from the following:
 - a. An outage of the main power in excess of the capability of any backup power source provided the automatic initiation of all backup sources was accomplished and that automatic shutdown and restart of the PACS performed as specified.
 - b. Failure of an Owner furnished equipment or communications link, provided the failure was not due to Contractor furnished equipment, installation, or software.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

28 05 00 - 72

Common Work Results for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

04-01-18

- c. Failure of existing Owner owned equipment, provided the failure was not due to Contractor furnished equipment, installation, or software.

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Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

28 05 00 - 73

Common Work Results for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-18

SECTION 28 05 13
CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the finishing, installation, connection, testing and certification of the conductors and cables required for a fully functional for electronic safety and security (ESS) system.

1.2 RELATED WORK

- A. Section 01 00 00 - GENERAL REQUIREMENTS. For General Requirements.
- B. Section 07 84 00 - FIRESTOPPING. Requirements for firestopping application and use.
- C. Section 28 05 00 - COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY. Requirements for general requirements that are common to more than one section in Division 28.
- D. Section 28 05 26 - GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY. Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- E. Section 28 05 28.33 - CONDUITS AND BOXES FOR ELECTRONIC SECURITY AND SAFETY. Requirements for infrastructure.
- F. Section 28 08 00 - COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY SYSTEMS. Requirements for commissioning.

1.3 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. EMI: Electromagnetic interference.
- C. IDC: Insulation displacement connector.
- D. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
- E. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 13 - 1

01/16/2024

Conductors and Cables for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-18

- F. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).
- G. RCDD: Registered Communications Distribution Designer.
- H. Solid-Bottom or Nonventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal side rails, and a bottom without ventilation openings.
- I. Trough or Ventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal rails and a bottom having openings sufficient for the passage of air and using 75 percent or less of the plan area of the surface to support cables.
- J. UTP: Unshielded twisted pair.

1.4 QUALITY ASSURANCE

- A. See section 28 05 00, Paragraph 1.4.

1.5 SUBMITTALS

- A. In accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, furnish the following:
 - 1. Manufacturer's Literature and Data: Showing each cable type and rating.
 - 2. Certificates: Two weeks prior to final inspection, deliver to the Resident Engineer/COTR four copies of the certification that the material is in accordance with the drawings and specifications and diagrams for cable management system.
 - 3. Shop Drawings: Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
 - a. Vertical and horizontal offsets and transitions.
 - b. Clearances for access above and to the side of cable trays.
 - c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
 - d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 13 - 2

01/16/2024

Conductors and Cables for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-18

- e. System labeling schedules, including electronic copy of labeling schedules that are part of the cable and asset identification system of the software specified in Parts 2 and 3.
- 4. Wiring Diagrams. Show typical wiring schematics including the following:
 - a. Workstation outlets, jacks, and jack assemblies.
 - b. Patch cords.
 - c. Patch panels.
- 5. Cable Administration Drawings: As specified in Part 3 "Identification" Article.
- 6. Project planning documents as specified in Part 3.
- 7. Maintenance Data: For wire and cable to include in maintenance manuals.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.
- B. American Society of Testing Material (ASTM):
 - D2301-04 Standard Specification for Vinyl Chloride Plastic Pressure Sensitive Electrical Insulating Tape
- C. Federal Specifications (Fed. Spec.):
 - A-A-59544-08 Cable and Wire, Electrical (Power, Fixed Installation)
- D. National Fire Protection Association (NFPA):
 - 70-11 National Electrical Code (NEC)
- E. Underwriters Laboratories, Inc. (UL):
 - 44-05 Thermoset-Insulated Wires and Cables
 - 83-08 Thermoplastic-Insulated Wires and Cables
 - 467-07 Electrical Grounding and Bonding Equipment

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 13 - 3

01/16/2024

Conductors and Cables for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-18

486A-03 Wire Connectors and Soldering Lugs for Use with
Copper Conductors
486C-04 Splicing Wire Connectors
486D-05 Insulated Wire Connector Systems for
Underground Use or in Damp or Wet Locations
486E-00 Equipment Wiring Terminals for Use with
Aluminum and/or Copper Conductors
493-07 Thermoplastic-Insulated Underground Feeder and
Branch Circuit Cable
514B-04 Fittings for Cable and Conduit
1479-03 Fire Tests of Through-Penetration Fire Stops

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
 - 1. Test each pair of UTP cables for open and short circuits.

1.8 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install UTP, optical fiber, and coaxial cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Support of Open Cabling: NRTL labeled for support of Category 6A cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
 - 1. Support brackets with cable tie slots for fastening cable ties to brackets.
 - 2. Lacing bars and spools.
 - 3. Straps and other devices.
- B. Conduit and Boxes: Comply with requirements in Division 28 Section "Conduits and Backboxes for Electrical Systems." [Flexible metal conduit shall not be used.]

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 13 - 4

01/16/2024

Conductors and Cables for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-18

1. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

2.2 UTP CABLE

- A. Description: 100-ohm, 4-pair UTP, formed into 25-pair binder groups covered with a blue thermoplastic jacket.
 1. Comply with ICEA S-90-661 for mechanical properties.
 2. Comply with TIA/EIA-568-B.1 for performance specifications.
 3. Comply with TIA/EIA-568-B.2, Category 6A.
 4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
 - a. Communications, General Purpose: Type CM or CMG.
 - b. Communications, Plenum Rated: Type CMP.
 - c. Communications, Riser Rated: Type CMR, complying with UL 1666.
 - d. Communications, Limited Purpose: Type CMX.
 - e. Multipurpose: Type MP or MPG.
 - f. Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
 - g. Multipurpose, Riser Rated: Type MPR, complying with UL 1666.

2.3 UTP CABLE HARDWARE

- A. UTP Cable Connecting Hardware: IDC type, using modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of the same category or higher.
- B. Connecting Blocks: 110-style for Category 6A. Provide blocks for the number of cables terminated on the block, plus [25] percent spare. Integral with connector bodies, including plugs and jacks where indicated.

2.4 RS-232 CABLE

- A. Standard Cable: NFPA 70, Type CM.
 1. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
 2. Polypropylene insulation.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 13 - 5

01/16/2024

Conductors and Cables for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-18

3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
 4. PVC jacket.
 5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 6. Flame Resistance: Comply with UL 1581.
- B. Plenum-Rated Cable: NFPA 70, Type CMP.
1. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
 2. Plastic insulation.
 3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
 4. Plastic jacket.
 5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 6. Flame Resistance: Comply with NFPA 262.

2.5 RS-485 CABLE

- A. Standard Cable: NFPA 70, Type CM [CMG.
1. Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.
 2. PVC insulation.
 3. Unshielded.
 4. PVC jacket.
 5. Flame Resistance: Comply with UL 1581.
- B. Plenum-Rated Cable: NFPA 70, Type CMP.
1. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
 2. Fluorinated ethylene propylene insulation.
 3. Unshielded.
 4. Fluorinated ethylene propylene jacket.
 5. Flame Resistance: NFPA 262, Flame Test.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 13 - 6

01/16/2024

Conductors and Cables for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-18

2.6 LOW-VOLTAGE CONTROL CABLE

- A. Paired Lock Cable: NFPA 70, Type CMG.
 - 1. 1 pair, twisted, No. 16 AWG, stranded (19x29) tinned copper conductors.
 - 2. PVC insulation.
 - 3. Unshielded.
 - 4. PVC jacket.
 - 5. Flame Resistance: Comply with UL 1581.
- B. Plenum-Rated, Paired Lock Cable: NFPA 70, Type CMP.
 - 1. 1 pair, twisted, No. 16 AWG, stranded (19x29) tinned copper conductors.
 - 2. PVC insulation.
 - 3. Unshielded.
 - 4. PVC jacket.
 - 5. Flame Resistance: Comply with NFPA 262.
- C. Paired Lock Cable: NFPA 70, Type CMG.
 - 1. 1 pair, twisted, No. 18 AWG, stranded (19x30) tinned copper conductors.
 - 2. PVC insulation.
 - 3. Unshielded.
 - 4. PVC jacket.
 - 5. Flame Resistance: Comply with UL 1581.
- D. Plenum-Rated, Paired Lock Cable: NFPA 70, Type CMP.
 - 1. 1 pair, twisted, No. 18 AWG, stranded (19x30) tinned copper conductors.
 - 2. Fluorinated ethylene propylene insulation.
 - 3. Unshielded.
 - 4. Plastic jacket.
 - 5. Flame Resistance: NFPA 262, Flame Test.

2.7 CONTROL-CIRCUIT CONDUCTORS

- A. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, in raceway complying with UL 83.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 13 - 7

01/16/2024

Conductors and Cables for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-18

- B. Class 2 Control Circuits: Stranded copper, [Type THHN-THWN, in raceway] [power-limited cable, concealed in building finishes] [power-limited tray cable, in cable tray] complying with UL 83.
- C. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or TF, complying with UL 83.

2.8 FIRE ALARM WIRE AND CABLE

- A. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
- B. Signaling Line Circuits: Twisted, shielded pair, [not less than] [No. 18 AWG] [<Insert wire size> AWG] [size as recommended by system manufacturer].
 - 1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a 2-hour rating.
- C. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.
 - 1. Low-Voltage Circuits: No. 16 AWG, minimum.
 - 2. Line-Voltage Circuits: No. 12 AWG, minimum.
 - 3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor [with outer jacket] with red identifier stripe, NRTL listed for fire alarm and cable tray installation, plenum rated, and complying with requirements in UL 2196 for a 2-hour rating.

2.9 IDENTIFICATION PRODUCTS

- A. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.10 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.
- C. Factory test UTP cables according to TIA/EIA-568-B.2.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 13 - 8

01/16/2024

Conductors and Cables for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-18

- D. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.
- E. Factory sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.
- F. Cable will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.

2.11 WIRE LUBRICATING COMPOUND

- A. Suitable for the wire insulation and conduit it is used with and shall not harden or become adhesive.
- B. Shall not be used on wire for isolated type electrical power systems.

2.12 FIREPROOFING TAPE

- A. The tape shall consist of a flexible, conformable fabric of organic composition coated one side with flame-retardant elastomer.
- B. The tape shall be self-extinguishing and shall not support combustion. It shall be arc-proof and fireproof.
- C. The tape shall not deteriorate when subjected to water, gases, salt water, sewage, or fungus and be resistant to sunlight and ultraviolet light.
- D. The finished application shall withstand a 200-ampere arc for not less than 30 seconds.
- E. Securing tape: Glass cloth electrical tape not less than 0.18 mm (7 mils) thick, and 19 mm (3/4 inch) wide.

PART 3 - EXECUTION

3.1 INSTALLATION OF CONDUCTORS AND CABLES

- A. Comply with NECA 1.
- B. General Requirements for Cabling:
 - 1. Comply with TIA/EIA-568-B.1.
 - 2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 13 - 9

01/16/2024

Conductors and Cables for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-18

3. Install 110-style IDC termination hardware unless otherwise indicated.
4. Terminate all conductors; no cable shall contain un-terminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
9. Pulling Cable:
 - a. Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
 - b. Provide installation equipment that will prevent the cutting or abrasion of insulation during pulling of cables.
 - c. Use ropes made of nonmetallic material for pulling feeders.
 - d. Attach pulling lines for feeders by means of either woven basket grips or pulling eyes attached directly to the conductors, as approved by the Resident Engineer/COTR.
 - e. Pull in multiple cables together in a single conduit.
- C. Splice cables and wires where necessary only in outlet boxes, junction boxes, or pull boxes.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 13 - 10

01/16/2024

Conductors and Cables for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-18

1. Splices and terminations shall be mechanically and electrically secure.
2. Where the Government determines that unsatisfactory splices or terminations have been installed, remove the devices and install approved devices at no additional cost to the Government.
- D. Seal cable and wire entering a building from underground, between the wire and conduit where the cable exits the conduit, with a non-hardening approved compound.
- E. Unless otherwise specified in other sections install wiring and connect to equipment/devices to perform the required functions as shown and specified.
- F. Except where otherwise required, install a separate power supply circuit for each system so that malfunctions in any system will not affect other systems.
- G. Where separate power supply circuits are not shown, connect the systems to the nearest panel boards of suitable voltages, which are intended to supply such systems and have suitable spare circuit breakers or space for installation.
- H. Install a red warning indicator on the handle of the branch circuit breaker for the power supply circuit for each system to prevent accidental de-energizing of the systems.
- I. System voltages shall be 120 volts or lower where shown on the drawings or as required by the NEC.
- J. UTP Cable Installation:
 1. Comply with TIA/EIA-568-B.2.
 2. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
- K. Optical Fiber Cable Installation:
 1. Comply with TIA/EIA-568-B.3.
 2. Cable shall be terminated on connecting hardware that is rack or cabinet mounted.
- L. Open-Cable Installation:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 13 - 11

01/16/2024

Conductors and Cables for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-18

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than [60 inches (1525 mm)] <Insert dimension> apart.
 3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
- M. Installation of Cable Routed Exposed under Raised Floors:
1. Install plenum-rated cable only.
 2. Install cabling after the flooring system has been installed in raised floor areas.
 3. Coil cable [72 inches (1830 mm)] <Insert size> long shall be neatly coiled not less than [12 inches (300 mm)] <Insert size> in diameter below each feed point.
- N. Outdoor Coaxial Cable Installation:
1. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors to keep out moisture.
 2. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches (915 mm).
- O. Separation from EMI Sources:
1. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
 2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 13 - 12

01/16/2024

Conductors and Cables for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-18

- b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
- c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 mm).
- 3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
- 4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (75 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
- 5. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
- 6. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.2 FIRE ALARM WIRING INSTALLATION

- A. Comply with NECA 1 and NFPA 72.
- B. Wiring Method: Install wiring in metal raceway according to Division 28 Section CONDUITS AND BACKBOXES FOR ELECTRICAL SYSTEMS."
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 13 - 13

01/16/2024

Conductors and Cables for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-18

2. Fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated raceway system. This system shall not be used for any other wire or cable.

C. Wiring Method:

1. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
2. Fire-Rated Cables: Use of 2-hour, fire-rated fire alarm cables, NFPA 70, Types MI and CI, is not permitted.
3. Signaling Line Circuits: Power-limited fire alarm cables [may] [shall not] be installed in the same cable or raceway as signaling line circuits.

D. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

E. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

F. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.

G. Risers: Install at least two vertical cable risers to serve the fire alarm system. Separate risers in close proximity to each other with a

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 13 - 14

01/16/2024

Conductors and Cables for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-18

minimum one-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signals from other floors or zones.

- H. Wiring to Remote Alarm Transmitting Device: 1-inch (25-mm) conduit between the fire alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

3.3 CONTROL CIRCUIT CONDUCTORS

- A. Minimum Conductor Sizes:
1. Class 1 remote-control and signal circuits, No. 14 AWG.
 2. Class 2 low-energy, remote-control and signal circuits, No. 16 AWG.
 3. Class 3 low-energy, remote-control, alarm and signal circuits, No. 12 AWG.

3.4 CONNECTIONS

- A. Comply with requirements in Division 28 Section, PHYSICAL ACCESS CONTROL for connecting, terminating, and identifying wires and cables.
- B. Comply with requirements in Division 28 Section "INTRUSION DETECTION" for connecting, terminating, and identifying wires and cables.
- C. Comply with requirements in Division 28 Section "VIDEO SURVEILLANCE" for connecting, terminating, and identifying wires and cables.
- D. Comply with requirements in Division 28 Section "ELECTRONIC PERSONAL PROTECTION SYSTEMS" for connecting, terminating, and identifying wires and cables.
- E. Comply with requirements in Division 28 Section "FIRE DETECTION AND ALARM" for connecting, terminating, and identifying wires and cables.

3.5 FIRESTOPPING

- A. Comply with requirements in Division 07 Section "PENETRATION FIRESTOPPING."
- B. Comply with TIA/EIA-569-A, "Firestopping" Annex A.
- C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.6 GROUNDING

- A. For communications wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 13 - 15

01/16/2024

Conductors and Cables for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-18

- B. For low-voltage wiring and cabling, comply with requirements in Division 28 Section "GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY."

3.7 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA/EIA-606.
- B. Install a permanent wire marker on each wire at each termination.
- C. Identifying numbers and letters on the wire markers shall correspond to those on the wiring diagrams used for installing the systems.
- D. Wire markers shall retain their markings after cleaning.
- E. In each handhole, install embossed brass tags to identify the system served and function.

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:
 - 1. Visually inspect UTP and optical fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments and inspect cabling connections to confirm compliance with TIA/EIA-568-B.1.
 - 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 3. Test UTP cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross connection.
 - a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 13 - 16

01/16/2024

Conductors and Cables for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-18

that are qualified by test equipment manufacturer for channel or link test configuration.

- D. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide or transfer the data from the instrument to the computer, save as text files, print, and submit.
- E. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.9 EXISTING WIRING

- A. Unless specifically indicated on the plans, existing wiring shall not be reused for the new installation. Only wiring that conforms to the specifications and applicable codes may be reused. If existing wiring does not meet these requirements, existing wiring may not be reused, and new wires shall be installed.

- - - E N D - - -

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 13 - 17

01/16/2024

Conductors and Cables for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

SECTION 28 05 26
GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the finishing, installation, connection, testing and certification of the grounding and bonding required for a fully functional Electronic Safety and Security (ESS) system.
- B. "Grounding electrode system" refers to all electrodes required by NEC, as well as including made, supplementary, grounding electrodes.
- C. The terms "connect", and "bond" are used interchangeably in this specification and have the same meaning

1.2 RELATED WORK

- A. Section 01 00 00 - GENERAL REQUIREMENTS. For General Requirements.
- B. Section 28 05 00 - REQUIREMENTS FOR ELECTRONIC SAFETY AND SECURITY INSTALLATIONS. For general electrical requirements, quality assurance, coordination, and project conditions that are common to more than one section in Division 28.
- C. Section 28 05 13 - CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY. Requirements for low voltage power and lighting wiring.
- D. Section 28 08 00 - COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY SYSTEMS. Requirements for commissioning.

1.3 SUBMITTALS

- A. Submit in accordance with Section 28 05 00, COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY.
- B. Shop Drawings:
 - 1. Clearly present enough information to determine compliance with drawings and specifications.
 - 2. Include the location of system grounding electrode connections and the routing of aboveground and underground grounding electrode conductors.
- C. Test Reports: Provide certified test reports of ground resistance.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 26 - 1

01/16/2024

Grounding and Bonding for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

- D. Certifications: Two weeks prior to final inspection, submit four copies of the following to the COTR.:
1. Certification that the materials and installation are in accordance with the drawings and specifications.
 2. Certification by the contractor that the complete installation has been properly installed and tested.

1.4 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. American Society for Testing and Materials (ASTM):
- B1-07 Standard Specification for Hard-Drawn Copper Wire
- B3-07 Standard Specification for Soft or Annealed Copper Wire
- B8-04 Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
- C. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
- 81-1983 IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
- C2-07 National Electrical Safety Code
- D. National Fire Protection Association (NFPA):
- 70-11 National Electrical Code (NEC)
- 99-2005 Health Care Facilities
- E. Underwriters Laboratories, Inc. (UL):
- 44-05 Thermoset-Insulated Wires and Cables
- 83-08 Thermoplastic-Insulated Wires and Cables
- 467-07 Grounding and Bonding Equipment
- 486A-486B-03 Wire Connectors

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 26 - 2

01/16/2024

Grounding and Bonding for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

PART 2 - PRODUCTS

2.1 GROUNDING AND BONDING CONDUCTORS

- A. Equipment grounding conductors shall be UL 83 insulated stranded copper, except that sizes 6 mm² (10 AWG) and smaller shall be solid copper. Insulation color shall be continuous green for all equipment grounding conductors, except that wire sizes 25 mm² (4 AWG) and larger shall be permitted to be identified per NEC.
- B. Bonding conductors shall be ASTM B8 bare stranded copper, except that sizes 6 mm² (10 AWG) and smaller shall be ASTM B1 solid bare copper wire.

2.2 SPLICES AND TERMINATION COMPONENTS

- A. Components shall meet or exceed UL 467 and be clearly marked with the manufacturer, catalog number, and permitted conductor size(s).2.4 ground connections
- B. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- C. Below Grade: Exothermic-welded type connectors.
- D. Above Grade:
 - 1. Bonding Jumpers: Compression-type connectors, using zinc-plated fasteners and external tooth lock washers.
 - 2. Connection to Building Steel: Exothermic-welded type connectors.
 - 3. Ground Busbars: Two-hole compression type lugs, using tin-plated copper or copper alloy bolts and nuts.
 - 4. Rack and Cabinet Ground Bars: One-hole compression-type lugs, using zinc-plated or copper alloy fasteners.
 - 5. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.
 - a) Pipe Connectors: Clamp type, sized for pipe.
 - 6. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 26 - 3

01/16/2024

Grounding and Bonding for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

2.3 GROUND TERMINAL BLOCKS

- A. At any equipment mounting location (e.g., backboards and hinged cover enclosures) where rack-type ground bars cannot be mounted, provide screw lug-type terminal blocks.

PART 3 - EXECUTION

3.1 GENERAL

- A. Ground in accordance with the NEC, as shown on drawings, and as specified herein.

3.2 INACCESSIBLE GROUNDING CONNECTIONS

- A. Make grounding connections, which are buried or otherwise normally inaccessible (except connections for which periodic testing access is required) by exothermic weld.

3.3 CORROSION INHIBITORS

- A. When making ground and ground bonding connections, apply a corrosion inhibitor to all contact surfaces. Use corrosion inhibitor appropriate for protecting a connection between the metals used.

3.4 COMPUTER ROOM/SECURITY EQUIPMENT ROOM GROUNDING

- A. Conduit: Ground and bond metallic conduit systems as follows:
1. Ground metallic service conduit and any pipes entering or being routed within the computer room at each end using 16 mm² (6AWG) bonding jumpers.
 2. Bond at all intermediate metallic enclosures and across all joints using 16 mm² (6 AWG) bonding jumpers.

3.5 WIREWAY GROUNDING

- A. Ground and Bond Metallic Wireway Systems as follows:
1. Bond the metallic structures of wireway to provide 100 percent electrical continuity throughout the wireway system by connecting a 16 mm² (6 AWG) bonding jumper at all intermediate metallic enclosures and across all section junctions.
 2. Install insulated 16 mm² (6 AWG) bonding jumpers between the wireway system bonded as required in paragraph 1 above, and the closest building ground at each end and approximately every 16 meters (50 feet).

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 26 - 4

01/16/2024

Grounding and Bonding for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

3. Use insulated 16 mm² (6 AWG) bonding jumpers to ground or bond metallic wireway at each end at all intermediate metallic enclosures and cross all section junctions.
4. Use insulated 16 mm² (6 AWG) bonding jumpers to ground cable tray to column-mounted building ground plates (pads) at each end and approximately every 15 meters.

3.6 GROUND RESISTANCE

- A. Grounding system resistance to ground shall not exceed 5 ohms. Make any modifications or additions to the grounding electrode system necessary for compliance without additional cost to the Government. Final tests shall ensure that this requirement is met.
- B. Resistance of the grounding electrode system shall be measured using a four-terminal fall-of-potential method as defined in IEEE 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not fewer than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

3.7 LABELING

- A. Comply with requirements in Division 26 Section "ELECTRICAL IDENTIFICATION" Article for instruction signs. The label or its text shall be green.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 1. After installing the grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 2. Inspect physical and mechanical conditions. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

28 05 26 - 5

01/16/2024

Grounding and Bonding for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal at individual ground rods. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Report measured ground resistances that exceed the following values:
 1. Power Distribution Units or Panel boards Serving Electronic Equipment: 3 ohm(s).
 2. Manhole Grounds: 10 ohms.
- F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

- - - E N D - - -

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

SECTION 28 05 28.33
CONDUITS AND BACKBOXES FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the finishing, installation, connection, testing certification of the conduit, fittings, and boxes to form a complete, coordinated, raceway system(s). Conduits and when approved separate UL Certified and Listed partitioned telecommunications raceways are required for a fully functional Electronic Safety and Security (ESS) system. Raceways are required for all electronic safety and security cabling unless shown or specified otherwise.
- B. Definitions: The term conduit, as used in this specification, shall mean any or all of the raceway types specified.

1.2 RELATED WORK

- A. Section 01 00 00 - GENERAL REQUIREMENTS. For General Requirements.
- B. Section 07 84 00 - FIRESTOPPING. Requirements for sealing around penetrations to maintain the integrity of fire rated construction.
- C. Section 07 92 00 - JOINT SEALANTS. Requirements for sealing around conduit penetrations through the building envelope to prevent moisture migration into the building.
- D. Section 09 91 00 - PAINTING. Requirements for identification and painting of conduit and other devices.
- E. Section 28 05 00 - COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY. For general electrical requirements, general arrangement of the contract documents, coordination, quality assurance, project conditions, equipment and materials, and items that is common to more than one section of Division 28.
- F. Section 28 05 26 - GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY. Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- G. Section 28 08 00 - COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY SYSTEMS. Requirements for commissioning - systems readiness checklists, and training.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 28.33 - 1

01/16/2024

Conduits and Backboxes for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. ENT: Electrical nonmetallic tubing.
- C. EPDM: Ethylene-propylene-diene terpolymer rubber.
- D. FMC: Flexible metal conduit.
- E. IMC: Intermediate metal conduit.
- F. LFMC: Liquid tight flexible metal conduit.
- G. LFNC: Liquid tight flexible nonmetallic conduit.
- H. NBR: Acrylonitrile-butadiene rubber.
- I. RNC: Rigid nonmetallic conduit.

1.4 QUALITY ASSURANCE

- A. Refer to Paragraph 1.4 Quality Assurance, in Section 28 05 00, COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY.

1.5 SUBMITTALS

- A. Submit in accordance with Section 28 05 00, COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY and Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. Furnish the following:
- B. Shop Drawings:
 - 1. Size and location of panels and pull boxes.
 - 2. Layout of required conduit penetrations through structural elements.
 - 3. The specific item proposed, and its area of application shall be identified on the catalog cuts.
- C. Certification: Prior to final inspection, deliver to the Resident Engineer/COTR four copies of the certification that the material is in accordance with the drawings and specifications and has been properly installed.
- D. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician, and dated on the date of completion, in accordance with the requirements of Section 28 08 00 COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY SYSTEMS.
- E. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

28 05 28.33 - 2

01/16/2024

Conduits and Backboxes for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

- F. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.
- G. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
1. Structural members in the paths of conduit groups with common supports.
 2. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.
- H. Source quality-control test reports.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.
- B. National Electrical Manufacturers Association (NEMA):
- TC-3-04 PVC Fittings for Use with Rigid PVC Conduit and
Tubing
- FB1-07 Fittings, Cast Metal Boxes and Conduit Bodies
for Conduit, Electrical Metallic Tubing and
Cable
- C. National Fire Protection Association (NFPA):
- 70-11 National Electrical Code (NEC)
- D. Underwriters Laboratories, Inc. (UL):
- 1-05 Flexible Metal Conduit
- 5-04 Surface Metal Raceway and Fittings
- 6-07 Rigid Metal Conduit
- 50-07 Enclosures for Electrical Equipment
- 360-09 Liquid-Tight Flexible Steel Conduit
- 467-07 Grounding and Bonding Equipment
- 514A-04 Metallic Outlet Boxes
- 514B-04 Fittings for Cable and Conduit
- 514C-02 Nonmetallic Outlet Boxes, Flush-Device Boxes
and Covers

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 28.33 - 3

01/16/2024

Conduits and Backboxes for Electronic Safety and Security

Conduits and Backboxes for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

- Bushings made entirely of metal or nonmetallic material are not permitted.
5. Erickson (union-type) and set screw type couplings: Approved for use in concrete are permitted for use to complete a conduit run where conduit is installed in concrete. Use set screws of case-hardened steel with hex head and cup point to firmly seat in conduit wall for positive ground. Tightening of set screws with pliers is prohibited.
 6. Sealing fittings: Threaded cast iron type. Use continuous drain type sealing fittings to prevent passage of water vapor. In concealed work, install fittings in flush steel boxes with blank cover plates having the same finishes as that of other electrical plates in the room.
- B. Rigid aluminum conduit fittings:
1. Standard threaded couplings, locknuts, bushings, and elbows: Malleable iron, steel, or aluminum alloy materials; Zinc or cadmium plate iron or steel fittings. Aluminum fittings containing more than 0.4 percent copper are prohibited.
 2. Locknuts and bushings: As specified for rigid steel and IMC conduit.
 3. Set screw fittings: Not permitted for use with aluminum conduit.
- C. Electrical metallic tubing fittings:
1. Fittings shall meet the requirements of UL 514B and ANSI/ NEMA FB1.
 2. Only steel or malleable iron materials are acceptable.
 3. Couplings and connectors: Concrete tight and rain tight, with connectors having insulated throats. Use gland and ring compression type couplings and connectors for conduit sizes 50 mm (2 inches) and smaller. Use set screw type couplings with four set screws each for conduit sizes over 50 mm (2 inches). Use set screws of case-hardened steel with hex head and cup point to firmly seat in wall of conduit for positive grounding.
 4. Indent type connectors or couplings are prohibited.
 5. Die-cast or pressure-cast zinc-alloy fittings or fittings made of "pot metal" are prohibited.
- D. Flexible steel conduit fittings:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 28.33 - 5

01/16/2024

Conduits and Backboxes for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

1. Conform to UL 514B. Only steel or malleable iron materials are acceptable.
2. Clamp type, with insulated throat.
- E. Liquid-tight flexible metal conduit fittings:
 1. Fittings shall meet the requirements of UL 514B and ANSI/ NEMA FB1.
 2. Only steel or malleable iron materials are acceptable.
 3. Fittings must incorporate a threaded grounding cone, a steel or plastic compression ring, and a gland for tightening. Connectors shall have insulated throats.
- F. Direct burial plastic conduit fittings:
 1. Fittings shall meet the requirements of UL 514C and NEMA TC3.
 2. As recommended by the conduit manufacturer.
- G. Surface metal raceway fittings: As recommended by the raceway manufacturer.
- H. Expansion and deflection couplings:
 1. Conform to UL 467 and UL 514B.
 2. Accommodate, 19 mm (0.75 inch) deflection, expansion, or contraction in any direction, and allow 30-degree angular deflections.
 3. Include internal flexible metal braid sized to guarantee conduit ground continuity and fault currents in accordance with UL 467, and the NEC code tables for ground conductors.
 4. Jacket: Flexible, corrosion-resistant, watertight, moisture and heat resistant molded rubber material with stainless steel jacket clamps.

2.5 CONDUIT SUPPORTS

- A. Parts and hardware: Zinc-coat or provide equivalent corrosion protection.
- B. Individual Conduit Hangers: Designed for the purpose, having a pre-assembled closure bolt and nut, and provisions for receiving a hanger rod.
- C. Multiple conduit (trapeze) hangers: Not less than 38 mm by 38 mm (1-1/2 by 1-1/2 inch), 12 gage steel, cold formed, lipped channels; with not less than 9 mm (3/8 inch) diameter steel hanger rods.
- D. Solid Masonry and Concrete Anchors: Self-drilling expansion shields, or machine bolt expansion.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 28.33 - 6

01/16/2024

Conduits and Backboxes for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

2.6 OUTLET, JUNCTION, AND PULL BOXES

- A. UL-50 and UL-514A.
- B. Cast metal where required by the NEC or shown and equipped with rustproof boxes.
- C. Nonmetallic Outlet and Device Boxes: NEMA OS 2.
- D. Metal Floor Boxes: Cast or sheet metal, semi-adjustable, rectangular.
- E. Sheet metal boxes: Galvanized steel, except where otherwise shown.
- F. Flush mounted wall or ceiling boxes shall be installed with raised covers so that front face of raised cover is flush with the wall. Surface mounted wall or ceiling boxes shall be installed with surface style flat or raised covers.

2.7 CABINETS

- A. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
- B. Hinged door in front cover with flush latch and concealed hinge.
- C. Key latch to match panelboards.
- D. Metal barriers to separate wiring of different systems and voltage.
- E. Accessory feet where required for freestanding equipment.

2.8 WIREWAYS

- A. Equip with hinged covers, except where removable covers are shown.

2.9 SLEEVES FOR RACEWAYS

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral water stop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch (1.3- or 3.5-mm) thickness as indicated and of length to suit application.
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 84 00 "FIRESTOPPING."

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 28.33 - 7

01/16/2024

Conduits and Backboxes for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

PART 3 - EXECUTION

3.1 PENETRATIONS

A. Cutting or Holes:

1. Locate holes in advance where they are proposed in the structural sections such as ribs or beams. Obtain the approval of the Resident Engineer/COTR prior to drilling through structural sections.
2. Cut holes through concrete and masonry in new and existing structures with a diamond core drill or concrete saw. Pneumatic hammer, impact electric, hand or manual hammer type drills are not allowed, except where permitted by the Resident Engineer/COTR as required by limited working space.

- B. Fire Stop: Where conduits, wireways, and other electronic safety and security raceways pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING, with rock wool fiber or silicone foam sealant only. Completely fill and seal clearances between raceways and openings with the fire stop material.

3.2 INSTALLATION, GENERAL

A. Install conduit as follows:

1. In complete runs before pulling in cables or wires.
2. Flattened, dented, or deformed conduit is not permitted. Remove and replace the damaged conduits with new undamaged material.
3. Assure conduit installation does not encroach into the ceiling height head room, walkways, or doorways.
4. Cut squares with a hacksaw, ream, remove burrs, and draw up tight.
5. Mechanically continuous.
6. Independently support conduit at 2.4 m (8 foot) on center. Do not use other supports i.e., (suspended ceilings, suspended ceiling supporting members, lighting fixtures, conduits, mechanical piping, or mechanical ducts).
7. Support within 300 mm (12 inches) of changes of direction, and within 300 mm (12 inches) of each enclosure to which connected.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 28.33 - 8

01/16/2024

Conduits and Backboxes for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

8. Close ends of empty conduit with plugs or caps at the rough-in stage to prevent entry of debris, until wires are pulled in.
 9. Conduit installations under fume and vent hoods are prohibited.
 10. Secure conduits to cabinets, junction boxes, pull boxes and outlet boxes with bonding type locknuts. For rigid and IMC conduit installations, provide a locknut on the inside of the enclosure, made up wrench tight. Do not make conduit connections to junction box covers.
 11. Flashing of penetrations of the roof membrane is specified in Section 07 60 00, "FLASHING AND SHEET METAL".
 12. Do not use aluminum conduits in wet locations.
 13. Unless otherwise indicated on the drawings or specified herein, all conduits shall be installed concealed within finished walls, floors and ceilings.
- B. Conduit Bends:
1. Make bends with standard conduit bending machines.
 2. Conduit hickey may be used for slight offsets, and for straightening stubbed out conduits.
 3. Bending of conduits with a pipe tee or vise is prohibited.
- C. Layout and Homeruns:
1. Install conduit with wiring, including homeruns, as shown.
 2. Deviations: Make only where necessary to avoid interferences and only after drawings showing the proposed deviations have been submitted approved by the Resident Engineer/COTR.
- D. Fire Alarm:
1. Fire alarm conduit shall be painted red (a red "top-coated" conduit from the conduit manufacturer may be used in lieu of painted conduit) in accordance with the requirements of Section 28 31 00, "FIRE DETECTION AND ALARM".

3.3 CONCEALED WORK INSTALLATION

A. In Concrete:

1. Conduit: Rigid steel, IMC or EMT. Do not install EMT in concrete slabs that are in contact with soil, gravel or vapor barriers.
2. Align and run conduit in direct lines.

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

28 05 28.33 - 9

01/16/2024

Conduits and Backboxes for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

3. Install conduit through concrete beams only when the following occurs:
 - a. Where shown on the structural drawings.
 - b. As approved by the Resident Engineer/COTR prior to construction, and after submittal of drawing showing location, size, and position of each penetration.
 4. Installation of conduit in concrete that is less than 75 mm (3 inch) thick is prohibited.
 - a. Conduit outside diameter larger than 1/3 of the slab thickness is prohibited.
 - b. Space between conduits in slabs: Approximately six conduit diameters apart, except one conduit diameter at conduit crossings.
 - c. Install conduits approximately in the center of the slab so that there will be a minimum of 19 mm (3/4 inch) of concrete around the conduits.
 5. Make couplings and connections watertight. Use thread compounds that are UL approved conductive type to ensure low resistance ground continuity through the conduits. Tightening set screws with pliers is prohibited.
- B. Furred or Suspended Ceilings and in Walls:
1. Conduit for conductors above 600 volts:
 - a. Rigid steel or rigid aluminum.
 - b. Aluminum conduit mixed indiscriminately with other types in the same system is prohibited.
 2. Conduit for conductors 600 volts and below:
 - a. Rigid steel, IMC, rigid aluminum, or EMT. Different type conduits mixed indiscriminately in the same system is prohibited.
 3. Align and run conduit parallel or perpendicular to the building lines.
 4. Connect recessed lighting fixtures to conduit runs with maximum 1800 mm (6 feet) of flexible metal conduit extending from a junction box to the fixture.
 5. Tightening set screws with pliers is prohibited.

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

28 05 28.33 - 10

01/16/2024

Conduits and Backboxes for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

3.4 EXPOSED WORK INSTALLATION

- A. Unless otherwise indicated on the drawings, exposed conduit is only permitted in mechanical and electrical rooms.
- B. Conduit for Conductors 600 volts and below:
 - 1. Rigid steel, IMC, rigid aluminum, or EMT. Different type of conduits mixed indiscriminately in the system is prohibited.
- C. Align and run conduit parallel or perpendicular to the building lines.
- D. Install horizontal runs close to the ceiling or beams and secure with conduit straps.
- E. Support horizontal or vertical runs at not over 2400 mm (eight foot) intervals.
- F. Surface metal raceways: Use only where shown.
- G. Painting:
 - 1. Paint exposed conduit as specified in Section 09 91 00, "PAINTING".
 - 2. Paint all conduits containing cables rated over 600 volts safety orange. Refer to Section 09 91 00, "PAINTING" for preparation, paint type, and exact color. In addition, paint legends, using 50 mm (two inch) high black numerals and letters, showing the cable voltage rating. Provide legends where conduits pass through walls and floors and at maximum 6000 mm (20 foot) intervals in between.

3.5 EXPANSION JOINTS

- A. Conduits 75 mm (3 inches) and larger, that are secured to the building structure on opposite sides of a building expansion joint, require expansion and deflection couplings. Install the couplings in accordance with the manufacturer's recommendations.
- B. Provide conduits smaller than 75 mm (3 inches) with junction boxes on both sides of the expansion joint. Connect conduits to junction boxes with sufficient slack of flexible conduit to produce 125 mm (5 inch) vertical drop midway between the ends. Flexible conduit shall have a green copper ground bonding jumper installed. In lieu of this flexible conduit, expansion and deflection couplings as specified above for 375 mm (15 inches) and larger conduits are acceptable.
- C. Install expansion and deflection couplings where shown.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 28.33 - 11

01/16/2024

Conduits and Backboxes for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

3.6 CONDUIT SUPPORTS, INSTALLATION

- A. Safe working load shall not exceed 1/4 of proof test load of fastening devices.
- B. Use pipe straps or individual conduit hangers for supporting individual conduits. The maximum distance between supports is 2.5 m (8 foot) on center.
- C. Support multiple conduits runs with trapeze hangers. Use trapeze hangers that are designed to support a load equal to or greater than the sum of the weights of the conduits, wires, hanger itself, and 90 kg (200 pounds). Attach each conduit with U-bolts or other approved fasteners.
- D. Support conduit independently of junction boxes, pull boxes, fixtures, suspended ceiling T-bars, angle supports, and similar items.
- E. Fasteners and Supports in Solid Masonry and Concrete:
 - 1. New Construction: Use steel or malleable iron concrete inserts set in place prior to placing the concrete.
 - 2. Existing Construction:
 - a. Steel expansion anchors not less than 6 mm (1/4 inch) bolt size and not less than 28 mm (1-1/8 inch) embedment.
 - b. Power set fasteners not less than 6 mm (1/4 inch) diameter with depth of penetration not less than 75 mm (3 inches).
 - c. Use vibration and shock resistant anchors and fasteners for attaching to concrete ceilings.
- F. Hollow Masonry: Toggle bolts are permitted.
- G. Bolts supported only by plaster or gypsum wallboard are not acceptable.
- H. Metal Structures: Use machine screw fasteners or other devices specifically designed and approved for the application.
- I. Attachment by wood plugs, rawl plug, plastic, lead or soft metal anchors, or wood blocking and bolts supported only by plaster is prohibited.
- J. Chain, wire, or perforated strap shall not be used to support or fasten conduit.
- K. Spring steel type supports, or fasteners are prohibited for all uses except: Horizontal and vertical supports/fasteners within walls.

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

28 05 28.33 - 12

01/16/2024

Conduits and Backboxes for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

- L. Vertical Supports: Vertical conduit runs shall have riser clamps and supports in accordance with the NEC and as shown. Provide supports for cable and wire with fittings that include internal wedges and retaining collars.

3.7 BOX INSTALLATION

- A. Boxes for Concealed Conduits:
1. Flush mounted.
 2. Provide raised covers for boxes to suit the wall or ceiling, construction, and finish.
- B. In addition to boxes shown, install additional boxes where needed to prevent damage to cables and wires during pulling in operations.
- C. Remove only knockouts as required and plug unused openings. Use threaded plugs for cast metal boxes and snap-in metal covers for sheet metal boxes.
- D. Outlet boxes in the same wall mounted back-to-back are prohibited. A minimum 600 mm (24 inch), center-to-center lateral spacing shall be maintained between boxes).
- E. Minimum size of outlet boxes for ground fault interrupter (GFI) receptacles is 100 mm (4 inches) square by 55 mm (2-1/8 inches) deep, with device covers for the wall material and thickness involved.
- F. Stencil or install phenolic nameplates on covers of the boxes identified on riser diagrams; for example "SIG-FA JB No. 1".
- G. On all Branch Circuit junction box covers, identify the circuits with black marker.

3.8 ELECTRONIC SAFETY AND SECURITY CONDUIT

- A. Install the electronic safety and security raceway system as shown on drawings.
- B. Minimum conduit size of 19 mm (3/4 inch), but not less than the size shown on the drawings.
- C. All conduit ends shall be equipped with insulated bushings.
- D. All 100 mm (four inch) conduits within buildings shall include pull boxes after every two 90-degree bends. Size boxes per the NEC.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 28.33 - 13

01/16/2024

Conduits and Backboxes for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

- E. Vertical conduits/sleeves through closets floors shall terminate not less than 75 mm (3 inches) below the floor and not less than 75 mm (3 inches) below the ceiling of the floor below.
- F. Terminate conduit runs to/from a backboard in a closet or interstitial space at the top or bottom of the backboard. Conduits shall enter communication closets next to the wall and be flush with the backboard.
- G. Where drilling is necessary for vertical conduits, locate holes so as not to affect structural sections such as ribs or beams.
- H. All empty conduits located in communications closets or on backboards shall be sealed with a standard non-hardening duct seal compound to prevent the entrance of moisture and gases and to meet fire resistance requirements.
- I. Conduit runs shall contain no more than four quarter turns (90-degree bends) between pull boxes/backboards. Minimum radius of communication conduit bends shall be as follows (special long radius):

Sizes of Conduit Trade Size	Radius of Conduit Bends mm, Inches
$\frac{3}{4}$	150 (6)
1	230 (9)
1-1/4	350 (14)
1-1/2	430 (17)
2	525 (21)
2-1/2	635 (25)
3	775 (31)
3-1/2	900 (36)
4	1125 (45)

- J. Furnish and pull wire in all empty conduits. (Sleeves through floor are exceptions).

3.9 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 28 08 00 - "COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY SYSTEMS" for all inspection, start up, and contractor testing required

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 28.33 - 14

01/16/2024

Conduits and Backboxes for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

above and required by the System Readiness Checklist provided by the Commissioning Agent.

- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 28 08 00, "COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY SYSTEMS" and related sections for contractor responsibilities for system commissioning.

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Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 05 28.33 - 15

01/16/2024

Conduits and Backboxes for Electronic Safety and Security

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-16

SECTION 28 08 00
COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The requirements of this Section apply to all sections of Division 28.
- B. This project will have selected building systems commissioned. The complete list of equipment and systems to be commissioned is specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. The commissioning process, which the Contractor is responsible to execute, is defined in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. A Commissioning Agent (CxA) appointed by the VA will manage the commissioning process.

1.2 RELATED WORK

- A. Section 01 00 00 GENERAL REQUIREMENTS.
- B. Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.
- C. Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

1.3 SUMMARY

- A. This Section includes requirements for commissioning the Facility electronic safety and security systems, related subsystems and related equipment. This Section supplements the general requirements specified in Section 01 91 00 General Commissioning Requirements.
- B. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for more details regarding processes and procedures as well as roles and responsibilities for all Commissioning Team members.

1.4 DEFINITIONS

- A. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for definitions.

1.5 COMMISSIONED SYSTEMS

- A. Commissioning of a system or systems specified in Division 28 is part of the construction process. Documentation and testing of these systems, as well as training of the VA's Operation and Maintenance personnel in accordance with the requirements of Section 01 91 00 and of Division 28, is required in cooperation with the VA and the Commissioning Agent.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 08 00 - 1

01/16/2024

Commissioning of Electronic Safety and Security Systems

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-16

- B. The Facility exterior closure systems commissioning will include the systems listed in Section 01 91 00 General Commissioning Requirements:

1.6 SUBMITTALS

- A. The commissioning process requires review of selected Submittals that pertain to the systems to be commissioned. The Commissioning Agent will provide a list of submittals that will be reviewed by the Commissioning Agent. This list will be reviewed and approved by the VA prior to forwarding to the Contractor. Refer to Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, and SAMPLES for further details.
- B. The commissioning process requires Submittal review simultaneously with engineering review. Specific submittal requirements related to the commissioning process are specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CONSTRUCTION INSPECTIONS

- A. Commissioning of Electronic Safety and Security systems will require inspection of individual elements of the electronic safety and security systems throughout the construction period. The Contractor shall coordinate with the Commissioning Agent in accordance with Section 01 91 00 and the Commissioning plan to schedule electronic safety and security systems inspections as required to support the Commissioning Process.

3.2 PRE-FUNCTIONAL CHECKLISTS

- A. The Contractor shall complete Pre-Functional Checklists to verify systems, subsystems, and equipment installation is complete and systems are ready for Systems Functional Performance Testing. The Commissioning Agent will prepare Pre-Functional Checklists to be used to document equipment installation. The Contractor shall complete the checklists. Completed checklists shall be submitted to the VA and to the Commissioning Agent for review. The Commissioning Agent may spot check a sample of completed checklists. If the Commissioning Agent determines that the information provided on the checklist is not accurate, the Commissioning Agent will return the marked-up checklist to the

Contract No. 36C26319D0044

Station Project No. 437-21-210

Bancroft-AE Project No. 22-113

28 08 00 - 2

01/16/2024

Commissioning of Electronic Safety and Security Systems

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-16

Contractor for correction and resubmission. If the Commissioning Agent determines that a significant number of completed checklists for similar equipment are not accurate, the Commissioning Agent will select a broader sample of checklists for review. If the Commissioning Agent determines that a significant number of the broader sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and resubmission. Refer to SECTION 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for submittal requirements for Pre-Functional Checklists, Equipment Startup Reports, and other commissioning documents.

3.3 CONTRACTORS TESTS

- A. Contractor tests as required by other sections of Division 28 shall be scheduled and documented in accordance with Section 01 00 00 GENERAL REQUIREMENTS. All testing shall be incorporated into the project schedule. Contractor shall provide no less than 7 calendar days' notice of testing. The Commissioning Agent will witness selected Contractor tests at the sole discretion of the Commissioning Agent. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.4 SYSTEMS FUNCTIONAL PERFORMANCE TESTING

- A. The Commissioning Process includes Systems Functional Performance Testing that is intended to test systems functional performance under steady state conditions, to test system reaction to changes in operating conditions, and system performance under emergency conditions. The Commissioning Agent will prepare detailed Systems Functional Performance Test procedures for review and approval by the Resident Engineer. The Contractor shall review and comment on the tests prior to approval. The Contractor shall provide the required labor, materials, and test equipment identified in the test procedure to perform the tests. The Commissioning Agent will witness and document the testing. The Contractor shall sign the test reports to verify tests were performed. See Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS, for additional details.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 08 00 - 3

01/16/2024

Commissioning of Electronic Safety and Security Systems

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

11-01-16

3.5 TRAINING OF VA PERSONNEL

- A. Training of the VA operation and maintenance personnel is required in cooperation with the COR and Commissioning Agent. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. Contractor shall submit training agendas and trainer resumes in accordance with the requirements of Section 01 91 00. The instruction shall be scheduled in coordination with the VA COR after submission and approval of formal training plans. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS and Division 28 Sections for additional Contractor training requirements.

----- END -----

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 08 00 - 4

01/16/2024

Commissioning of Electronic Safety and Security Systems

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

SECTION 28 13 00
PHYSICAL ACCESS CONTROL SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide PACS components, hardware, cabling, terminations, programming, licensing, testing, commissioning and required labor as shown on the contact documents and described herein. This is an extension of the PACS currently in place. This section specifies the finishing, installation, connection, testing, and certification of a complete and fully operating Physical Access Control System, hereinafter referred to as the PACS.
- B. System Architecture:
 - 1. Criticality, operational requirements, and/or limiting points of failure may dictate the development of an enterprise and regional server architecture as opposed to system capacity. Provide server and workstation configurations with all necessary connectors, interfaces and accessories as shown.
- C. PACS shall provide secure and reliable identification of Federal employees and contractors by utilizing credential authentication per FIPS-201.
- D. Physical Access Control System (PACS) shall consist of:
 - 1. Head-End equipment server,
 - 2. One or more networked PC-based workstations,
 - 3. Physical Access Control System and Database Management Software,
 - 4. Credential validation software/hardware,
 - 5. Field installed controllers,
 - 6. PIV Middleware,
 - 7. Card readers,
 - 8. Biometric identification devices,
 - 9. PIV-I cards,
 - 10. Supportive information system,
 - 11. Door locks and sensors,
 - 12. Power supplies,
 - 13. Interfaces with:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- a. Video Surveillance and Assessment System,
 - b. Gate, turnstile, and traffic arm controls,
 - c. Automatic door operators,
 - d. Intrusion Detection System,
 - e. Intercommunication System
 - f. Fire Protection System,
 - g. HVAC,
 - h. Building Management System,
 - i. Elevator Controls,
- E. Head-End equipment server, workstations and controllers shall be connected by a high-speed electronic data transmission network.
- F. Information system supporting PACS, Head-End equipment server, workstations, network switches, routers and controllers shall comply with FIPS 200 requirements (Minimum Security Requirements for Federal Information and Information Systems) and NIST Special Publication 800-53 (Recommended Security Controls for Federal Information Systems).
- G. PACS system shall support:
- 1. Multiple credential authentication modes,
 - 2. Bidirectional communication with the reader,
 - 3. Incident response policy implementation capability; system shall have capability to automatically change access privileges for certain user groups to high security areas in case of incident/emergency.
 - 4. Visitor management,
- H. All security relevant decisions shall be made on "secure side of the door." Secure side processing shall include.
- 1. Challenge/response management,
 - 2. PKI path discovery and validation,
 - 3. Credential identifier processing,
 - 4. Authorization decisions.
- I. For locations where secure side processing is not applicable the tamper switches and certified cryptographic processing shall be provided per FIPS-140-2.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- J. System Software: Based on existing installed system, central-station, workstation operating system, server operating system, and application software.
- K. Software and controllers shall be capable of matching full 56-bit FASC-N plus minimum of 32 bits of public key certificate data.
- L. Software shall have the following capabilities:
1. Multiuser multitasking to allow for independent activities and monitoring to occur simultaneously at different workstations.
 2. Support authentication and enrolment.
 - a. PIV verification,
 - b. Expiration date check,
 - c. Biometric check,
 - d. Digital photo display/check,
 - e. Validate digital signatures of data objects (Objects are signed by the Trusted Authority
 - f. Private key challenge (CAK & PAK to verify private key public key pairs exist and card is not a clone)
 3. Support CRL validation via OCSP or SCVP on a scheduled basis and automatically deny access to any revoked credential in the system.
 4. Graphical user interface to show pull-down menus and a menu tree format that complies with interface guidelines of Microsoft Windows operating system.
 5. System license shall be for the entire system and shall include capability for future additions that are within the indicated system size limits specified in this Section.
 6. System shall have open architecture that allows importing and exporting of data and interfacing with other systems that are compatible with the existing installed operating system.
 7. Operator login and access shall be utilized via integrated smart card reader and password protection.
- M. Systems Networks:
1. A standalone system network shall interconnect all components of the system. This network shall include communications between a central station and any peer or subordinate workstations, enrollment

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

stations, local annunciation stations, portal control stations or
redundant central stations.

1.2 RELATED WORK.

- A. Section 01 00 00 - GENERAL REQUIREMENTS. For General Requirements.
- B. Section 07 84 00 - FIRESTOPPING. Requirements for firestopping application and use.
- C. Section 08 71 00 - DOOR HARDWARE. Requirements for door installation.
- D. Section 10 14 00 - SIGNAGE. Requirements for labeling and signs.
- E. Section 26 05 11 - REQUIREMENTS FOR ELECTRICAL INSTALLATIONS. Requirements for connection of high voltage.
- F. Section 26 05 21 - LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW). Requirements for power cables.
- G. Section 26 05 33 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS. Requirements for infrastructure.
- H. Section 28 05 00 - COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY. For general requirements that are common to more than one section in Division 28.
- I. Section 28 05 13 - CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY. Requirements for conductors and cables.
- J. Section 28 05 26 - GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY. Requirements for grounding of equipment.
- K. Section 28 05 28.33 - CONDUITS AND BOXES FOR ELECTRONIC SAFETY AND SECURITY. Requirements for infrastructure.
- L. Section 28 08 00 - COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY. For requirements for commissioning, systems readiness checklists, and training.
- M. Section 28 13 16 - ACCESS CONTROL SYSTEM AND DATABASE MANAGEMENT. Requirements for control and operation of all security systems.
- N. Section 28 13 53 - SECURITY ACCESS DETECTION. Requirements for screening of personnel and shipments.
- O. Section 28 23 00 - VIDEO SURVEILLANCE. Requirements for security camera systems.
- P. Section 28 31 00 - FIRE DETECTION AND ALARM. Requirements for integration with fire detection and alarm system.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 13 00 - 4
Physical Access Control System

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

1.3 QUALITY ASSURANCE

- A. Refer to 25 05 00 COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY, Part 1

1.4 SUBMITTALS

- A. Refer to 25 05 00 COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY, Part 11

1.5 APPLICABLE PUBLICATIONS

- A. Refer to 25 05 00 COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY, Part 1

1.6 DEFINITIONS

- A. Refer to 25 05 00 COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY, Part 1

1.8 MAINTENANCE & SERVICE

- A. Refer to 25 05 00 COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY, Part 1

1.9 PERFORMANCE REQUIREMENTS

- A. PACS shall provide support for multiple authentication modes and bidirectional communication with the reader. PACS shall provide implementation capability for enterprise security policy and incident response.
- B. All processing of authentication information must occur on the "safe side" of a door
- C. Physical Access Control System shall provide access to following Security Areas:
 - 1. Controlled
 - 2. Limited
 - 3. Exclusion
- D. PACS shall provide:
 - 1. One authentication factor for access to Controlled security areas
 - 2. Two authentication factors for access to Limited security areas
 - 3. Three authentication factors for access to Exclusion security areas
- E. PACS shall provide Credential Validation and Path Validation per NIST 800-116.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 13 00 - 5
Physical Access Control System

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- F. The PACS System shall have an Enterprise Path Validation Module (PVM) component that processes X.509 certification paths composed of X.509 v3 certificates and X.509 v2 CRLs. The PVM component MUST support the following features:
1. Name chaining.
 2. Signature chaining.
 3. Certificate validity.
 4. Key usage, basic constraints, and certificate policies certificate extensions.
 5. Full CRLs; and
 6. CRLs segmented on names.
- G. Distributed Processing: System shall be a fully distributed processing system so that information, including time, date, valid codes, access levels, and similar data, is downloaded to Controllers so that each Controller makes access-control decisions for that Location. Do not use intermediate Controllers for physical access control. If communications to Central Station are lost, all Controllers shall automatically buffer event transactions until communications are restored, at which time buffered events shall be uploaded to the Central Station.
- H. System Network Requirements:
1. Interconnect system components and provide automatic communication of status changes, commands, field-initiated interruptions, and other communications required for proper system operation.
 2. Communication shall not require operator initiation or response and shall return to normal after partial or total network interruption such as power loss or transient upset.
 3. System shall automatically annunciate communication failures to the operator and identify the communication link that has experienced a partial or total failure.
 4. Communications Controller may be used as an interface between the Central Station display systems and the field device network.
Communications Controller shall provide functions required to attain the specified network communications performance.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- I. Central Station shall provide operator interface, interaction, display, control, and dynamic and real-time monitoring. Central Station shall control system networks to interconnect all system components, including workstations and field-installed Controllers.
- J. Field equipment shall include Controllers, sensors, and controls. Controllers shall serve as an interface between the Central Station and sensors and controls. Data exchange between the Central Station and the Controllers shall include down-line transmission of commands, software, and databases to Controllers. The up-line data exchange from the Controller to the Central Station shall include status data such as intrusion alarms, status reports, and entry-control records. Controllers are classified as alarm-annunciation or entry-control type.
- K. System Response to Alarms: Field device network shall provide a system end-to-end response time of [1] second(s) or less for every device connected to the system. Alarms shall be annunciated at the Central Station within 1 second of the alarm occurring at a Controller or device controlled by a local Controller, and within 100 ms if the alarm occurs at the Central Station. Alarm and status changes shall be displayed within 100 ms after receipt of data by the Central Station. All graphics shall be displayed, including graphics-generated map displays, on the console monitor within 5 seconds of alarm receipt at the security console. [This response time shall be maintained during system heavy load.]
- L. False Alarm Reduction: The design of Central Station and Controllers shall contain features to reduce false alarms. Equipment and software shall comply with SIA CP-01.
- M. Error Detection: A cyclic code error detection method shall be used between Controllers and the Central Station, which shall detect single- and double-bit errors, burst errors of eight bits or less, and at least 99 percent of all other multibit and burst error conditions. Interactive or product error detection codes alone will not be acceptable. A message shall be in error if one bit is received incorrectly. System shall retransmit messages with detected errors. A two-digit decimal number shall be operator assignable to each

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

communication link representing the number of retransmission attempts.

When the number of consecutive retransmission attempts equals the assigned quantity, the Central Station shall print a communication failure alarm message. System shall monitor the frequency of data transmission failure for display and logging.

- N. Data Line Supervision: System shall initiate an alarm in response to opening, closing, shorting, or grounding of data transmission lines.
- O. Door Hardware Interface: Coordinate with Division 08 Sections that specify door hardware required to be monitored or controlled by the PACS. The Controllers in this Section shall have electrical characteristics that match the signal and power requirements of door hardware. Integrate door hardware specified in Division 08 Sections to function with the controls and PC-based software and hardware in this Section.
- P. References to industry and trade association standards and codes are minimum installation requirement standards.
- Q. Drawings and other specification sections shall govern in those instances where requirements are greater than those specified in the above standards.

1.10 EQUIPMENT AND MATERIALS

- A. Refer to 25 05 00 COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY, Part 1

1.11 WARRANTY OF CONSTRUCTION.

- A. Warrant PACS work subject to the Article "Warranty of Construction" of FAR clause 52.246-21.
- B. Demonstration and training shall be performed prior to system acceptance.

1.12 GENERAL REQUIREMENTS

- A. For general requirements that are common to more than one section in Division 28 refer to Section 28 05 00, REQUIREMENTS FOR ELECTRONIC SAFETY AND SECURITY INSTALLATIONS.
- B. General requirements applicable to this section include:
 - 1. General Arrangement of Contract Documents,
 - 2. Delivery, Handling and Storage,

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

3. Project Conditions,
4. Electrical Power,
5. Lightning, Power Surge Suppression, and Grounding,
6. Electronic Components,
7. Substitute Materials and Equipment, and
8. Like Items.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All equipment and materials for the system will be compatible to ensure correct operation as outlined in FIPS 201, March 2006 and HSPD-12.
- B. The security system characteristics listed in this section will serve as a guide in selection of equipment and materials for the PACS. If updated or more suitable versions are available, then the Contracting Officer will approve the acceptance of prior to an installation.
- C. PACS equipment shall meet or exceed all requirements listed below.
- D. A PACS shall be comprised of, but not limited to, the following components:
 1. Physical Access Control System
 2. Application Software
 3. System Database
 4. Surge and Tamper Protection
 5. Standard Workstation Hardware
 6. Communications Workstation
 7. Controllers (Data Gathering Panel)
 8. Secondary Alarm Annunciator
 9. Keypads
 10. Card Readers
 11. Credential Cards
 12. Biometric Identity Verification Equipment
 13. Enrolment Center (To be provided in accordance with the VA PIV enrollment and issuance system.)
 14. System Sensors and Related Equipment
 15. Push Button Switches
 16. Interfaces

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 13 00 - 9
Physical Access Control System

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

17. Door and Gate Hardware interface
18. RS-232 ASCII Interface
19. Floor Select Elevator Control
20. After-Hours HVAC Control
21. Real Time Guard Tour
22. Video and Camera Control
23. Cables
24. Transformers

2.2 SECURITY MANAGEMENT SYSTEM (SMS)

- A. Shall allow the configuration of an enrollment and badging, alarm monitoring, administrative, asset management, digital video management, intrusion detection, visitor enrollment, remote access level management, and integrated client workstations or any combination of all or some.
- B. Shall be expandable to support an unlimited number of individual module or integrated client workstations. All access control field hardware, including Data Gathering Panels (DGP), shall be connected to all physical access control system workstation on the network.
- C. Shall have the ability to compose, file, maintain, update, and print reports for either individuals or the system as follows.
 1. Individual reports that consist of an employee's name, office location, phone number or direct extension, and normal hours of operation. The report shall provide a detail listing of the employee's daily events in relation to accessing points within a facility.
 2. System reports shall be able to produce information on a daily/weekly/monthly basis for all events, alarms, and any other activity associated with a system user.
- D. All reports shall be in a date/time format and all information shall be clearly presented. Shall be designed to allow it to work with any industry standard network protocol and topology listed below:
 1. Transmission Control Protocol (TCP)/IP
 2. Novell Netware (IPX/SPX)
 3. Banyan VINES

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 13 00 - 10
Physical Access Control System

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

4. IBM LAN-Server (NetBEUI)
 5. Microsoft LAN-Manager (NetBEUI)
 6. Network File System (NFS) Networks
 7. Remote Access Service (RAS) via ISDN, x.25, and standard phone lines.
- E. Shall provide full interface and control of the PACS to include the following subsystems within the PACS:
1. Public Key Infrastructure
 2. Card Management
 3. Identity and Access Management
 4. Personal Identity Verification
- F. Shall have the following features or compatibilities:
1. The ability to be operated locally or remotely via a LAN, WAN, internet, or intranet.
 2. Event and Alarm Monitoring
 3. Database Partitioning
 4. Ability to fully integrate with all other security subsystems
 5. Enhanced Monitoring Station with Split Screen Views
 6. Alternate and Extended Shunt by Door
 7. Escort Management
 8. Enhanced IT-based Password Protection
 10. N-man Rule and Occupancy Restrictions
 11. Open Journal Data Format for Enhanced Reporting
 12. Automated Personnel Import
 13. ODBC Support
 14. Windows 2000 Professional, Windows Server 2003, Windows XP Professionals for Servers, Windows 7
 15. Field-Level Audit Trail
 16. Cardholder Access Events

2.3 APPLICATION SOFTWARE

- A. System Software: Based on 32 bit, [Microsoft Windows central-station and workstation operating system and application software. Software shall have the following features:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 13 00 - 11
Physical Access Control System

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

1. Multiuser multitasking to allow independent activities and monitoring to occur simultaneously at different workstations.
 2. Graphical user interface to show pull-down menus and a menu tree format.
 3. Capability for future additions within the indicated system size limits.
 4. Open architecture that allows importing and exporting of data and interfacing with other systems that are compatible with operating system.
 5. Password-protected operator and smart card login and access.
- B. Peer Computer Control Software: Shall detect a failure of a central computer and shall cause the other central computer to assume control of all system functions without interruption of operation. Drivers shall be provided in both central computers to support this mode of operation.
- C. Application Software: Interface between the alarm annunciation and entry-control Controllers, to monitor sensors [and DTS links], operate displays, report alarms, generate reports, and help train system operators. Software shall have the following functions:
1. Resides at the Central Station, workstations, and Controllers as required to perform specified functions.
 2. Operate and manage peripheral devices.
 3. Manage files for disk I/O, including creating, deleting, and copying files; and automatically maintain a directory of all files, including size and location of each sequential and random-ordered record.
 4. Import custom icons into graphics views to represent alarms and I/O devices.
 5. Globally link I/O so that any I/O can link to any other I/O within the same Location, without requiring interaction with the host PC. This operation shall be at the Controller.
 6. Globally code I/O links so that any access-granted event can link to any I/O with the same Location without requiring interaction with the host PC. This operation shall be at the Controller.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 13 00 - 12
Physical Access Control System

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

7. Messages from PC to Controllers and Controllers to Controllers shall be on a polled network that utilizes check summing and acknowledgment of each message. Communication shall be automatically verified, buffered, and retransmitted if message is not acknowledged.
8. Selectable poll frequency and message time-out settings shall handle bandwidth and latency issues for TCP/IP, RF, and other PC-to-Controller communications methods by changing the polling frequency and the amount of time the system waits for a response.
9. Automatic and encrypted backups for database and history backups shall be automatically stored at [the central control PC] [a selected workstation] and encrypted with a nine-character alphanumeric password, which must be used to restore or read data contained in backup.
10. Operator audit trail for recording and reporting all changes made to database and system software.

D. Workstation Software:

1. Password levels shall be individually customized at each workstation to allow or disallow operator access to program functions for each Location.
2. Workstation event filtering shall allow user to define events and alarms that will be displayed at each workstation. If an alarm is unacknowledged (not handled by another workstation) for a preset amount of time, the alarm will automatically appear on the filtered workstation.

E. Controller Software:

1. Controllers shall operate as an autonomous intelligent processing unit. Controllers shall make decisions about physical access control, alarm monitoring, linking functions, and door locking schedules for its operation, independent of other system components. Controllers shall be part of a fully distributed processing control network. The portion of the database associated with a Controller and consisting of parameters, constraints, and the latest value or

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

status of points connected to that Controller, shall be maintained in the Controller.

2. Functions: The following functions shall be fully implemented and operational within each Controller:

- a. Monitoring inputs.
- b. Controlling outputs.
- c. Automatically reporting alarms to the Central Station.
- d. Reporting of sensor and output status to Central Station on request.
- e. Maintaining real time, automatically updated by the Central Station at least once a day.
- f. Communicating with the Central Station.
- g. Executing Controller resident programs.
- h. Diagnosing.
- i. Downloading and uploading data to and from the Central Station.

3. Controller Operations at a Location:

- a. Location: Up to [64] Controllers connected to RS-485 communications loop. Globally operating I/O linking and anti-passback functions between Controllers within the same Location without central-station or workstation intervention. Linking and anti-passback shall remain fully functional within the same Location even when the Central Station or workstations are offline.
- b. In the event of communications failure between the Central Station and a Location, there shall be no degradation in operations at the Controllers at that Location. The Controllers at each Location shall be connected to a memory buffer with a capacity to store up to 10,000 events; there shall be no loss of transactions in system history files until the buffer overflows.
- c. Buffered events shall be handled in a first-in-first-out mode of operation.

4. Individual Controller Operation:

- a. Controllers shall transmit alarms, status changes, and other data to the Central Station when communications circuits are operable.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 13 00 - 14
Physical Access Control System

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

If communications are not available, Controllers shall function in a stand-alone mode and operational data, including the status and alarm data normally transmitted to the Central Station, shall be stored for later transmission to the Central Station. Storage capacity for the latest 1024 events shall be provided at each Controller.

- b. Card-reader ports of a Controller shall be custom configurable for at least [120] different card-reader or keypad formats. Multiple reader or keypad formats may be used simultaneously at different Controllers or within the same Controller.
 - c. Controllers shall provide a response to card-readers or keypad entries in less than 0.25 seconds, regardless of system size.
 - d. Controllers that are reset, or powered up from a nonpowered state, shall automatically request a parameter download and reboot to its proper working state. This shall happen without any operator intervention.
 - e. Initial Startup: When Controllers are brought on-line, database parameters shall be automatically downloaded to them. After initial download is completed, only database changes shall be downloaded to each Controller.
 - f. Failure Mode: On failure for any reason, Controllers shall perform an orderly shutdown and force Controller outputs to a predetermined failure mode state, consistent with the failure modes shown and the associated control device.
 - g. Startup After Power Failure: After power is restored, startup software shall initiate self-test diagnostic routines, after which Controllers shall resume normal operation.
 - h. Startup After Controller Failure: On failure, if the database and application software are no longer resident, Controllers shall not restart, but shall remain in the failure mode until repaired. If database and application programs are resident, Controllers shall immediately resume operation. If not, software shall be restored automatically from the Central Station.
5. Communications Monitoring:

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- a. System shall monitor and report status of RS-485 communications loop [TCP/IP communication status] of each Location.
 - b. Communication status window shall display which Controllers are currently communicating, a total count of missed polls since midnight, and which Controller last missed a poll.
 - c. Communication status window shall show the type of CPU, the type of I/O board, and the amount of RAM memory for each Controller.
6. Operating systems shall include a real-time clock function that maintains seconds, minutes, hours, day, date, and month. The real-time clock shall be automatically synchronized with the Central Station at least once a day to plus or minus 10 seconds. The time synchronization shall be automatic, without operator action and without requiring system shutdown.
- F. PC-to-Controller Communications:
1. Central-station or workstation communications shall use the following:
 - a. Direct connection using serial ports of the PC.
 - b. TCP/IP LAN network interface cards.
 - c. Dial-up modems for connections to Locations.
 2. Serial Port Configuration: Each serial port used for communications shall be individually configurable for "direct communications," "modem communications incoming and outgoing," or "modem communications incoming only"; or as an ASCII output port.
 3. Multiport Communications Board: Use if more than two serial ports are needed.
 - a. Expandable and modular design. Use a 4-, 8-, or 16-serial port configuration that is expandable to 32 or 64 serial ports.
 - b. Connect the first board to an internal PCI bus adapter card.
 4. Direct serial, TCP/IP, and dial-up communications shall be alike in the monitoring or control of system, except for the connection that must first be made to a dial-up Location.
 5. TCP/IP network interface card shall have an option to set the poll frequency and message response time-out settings.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

6. PC-to-Controller and Controller-to-Controller communications (direct, dial-up, or TCP/IP) shall use a polled-communication protocol that checks sum and acknowledges each message. All communications shall be verified and buffered and retransmitted if not acknowledged.
- G. Direct Serial or TCP/IP PC-to-Controller Communications:
1. Communication software on the PC shall supervise the PC-to-Controller communications link.
 2. Loss of communications to any Controller shall result in an alarm at all PCs running the communications software.
 3. When communications are restored, all buffered events shall automatically upload to the PC, and any database changes shall be automatically sent to the Controller.
- H. Dial-up Modem PC-to-Controller Communications:
1. Communication software on the PC shall supervise the PC-to-Controller communications link during dial-up modem connect times.
 2. Communication software shall be programmable to routinely poll each of the remote dial-up modem Locations, collecting event logs and verifying phone lines at time intervals that are operator selectable for each Location.
 3. System shall be programmable for dialing and connecting to all dial-up modem Locations and for retrieving the accrued history transactions on an automatic basis as often as once every 10 minutes and up to once every 9999 minutes.
 4. Failure to communicate to a dial-up Location three times in a row shall result in an alarm at the PC.
 5. Time offset capabilities shall be present so that Locations in a different geographical time zone than the host PC will be set to, and maintained at, the proper local time. This feature shall allow for geographical time zones that are ahead of or behind the host PC.
 6. The Controller connected to a dial-up modem shall automatically buffer all normal transactions until its buffer reaches 80 percent of capacity. When the transaction buffer reaches 80 percent, the

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

Controller shall automatically initiate a call to the Central Station and upload all transactions.

7. Alarms shall be reported immediately.
8. Dial-up modems shall be provided by manufacturer of the system. Modems used at the Controller shall be powered by the Controller. Power to the modem shall include battery backup if the Controller is so equipped.

I. Controller-to-Controller Communications:

1. Controller-to-Controller Communications: RS-485, 4-wire, point-to-point, regenerative (repeater) communications network methodology.
2. RS-485 communications signal shall be regenerated at each Controller.

J. Database Downloads:

1. All data transmissions from PCs to a Location, and between Controllers at a Location, shall include a complete database checksum to check the integrity of the transmission. If the data checksum does not match, a full data download shall be automatically retransmitted.
2. If a Controller is reset for any reason, it shall automatically request and receive a database download from the PC. The download shall restore data stored at the Controller to their normal working state and shall take place with no operator intervention.

K. Operator Interface:

1. Inputs in system shall have two icon representations, one for the normal state and one for the abnormal state.
2. When viewing and controlling inputs, displayed icons shall automatically change to the proper icon to display the current system state in real time. Icons shall also display the input's state, whether armed or bypassed, and if the input is in the armed or bypassed state due to a time zone or a manual command.
3. Outputs in system shall have two icon representations, one for the secure (locked) state and one for the open (unlocked) state.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

4. Icons displaying status of the I/O points shall be constantly updated to show their current real-time condition without prompting by the operator.
5. The operator shall be able to scroll the list of I/Os and press the appropriate toolbar button, or right click, to command the system to perform the desired function.
6. Graphic maps or drawings containing inputs, outputs, and override groups shall include the following:
 - a. Database to import and store full-color maps or drawings and allow for input, output, and override group icons to be placed on maps.
 - b. Maps to provide real-time display animation and allow for control of points assigned to them.
 - c. System to allow inputs, outputs, and override groups to be placed on different maps.
 - d. Software to allow changing the order or priority in which maps will be displayed.
7. Override Groups Containing I/Os:
 - a. System shall incorporate override groups that provide the operator with the status and control over user-defined "sets" of I/Os with a single icon.
 - b. Icon shall change automatically to show the live summary status of points in that group.
 - c. Override group icon shall provide a method to manually control or set to time zone points in the group.
 - d. Override group icon shall allow the expanding of the group to show icons representing the live status for each point in the group, individual control over each point, and the ability to compress the individual icons back into one summary icon.
8. Schedule Overrides of I/Os and Override Groups:
 - a. To accommodate temporary schedule changes that do not fall within the holiday parameters, the operator shall have the ability to override schedules individually for each input, output, or override group.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 13 00 - 19
Physical Access Control System

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- b. Each schedule shall be composed of a minimum of two dates with separate times for each date.
- c. The first time and date shall be assigned the override state that the point shall advance to, when the time and date become current.
- d. The second time and date shall be assigned the state that the point shall return to, when the time and date become current.
- 9. Copy command in database shall allow for like data to be copied and then edited for specific requirements, to reduce redundant data entry.

L. Operator Access Control:

- 1. Control operator access to system controls through [three] password-protected operator levels. System operators and managers with appropriate password clearances shall be able to change operator levels for operators.
- 2. Three successive attempts by an operator to execute functions beyond their defined level during a 24-hour period shall initiate a software tamper alarm.
- 3. A minimum of 32 passwords shall be available with the system software. System shall display the operator's name or initials in the console's first field. System shall print the operator's name or initials, action, date, and time on the system printer at login and logoff.
- 4. The password shall not be displayed or printed.
- 5. Each password shall be definable and assignable for the following:
 - a. Commands usable.
 - b. Access to system software.
 - c. Access to application software.
 - d. Individual zones that are to be accessed.
 - e. Access to database.

M. Operator Commands:

- 1. Command Input: Plain-language words and acronyms shall allow operators to use the system without extensive training or data-

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- processing backgrounds. System prompts shall be a word, a phrase, or an acronym.
2. Command inputs shall be acknowledged, and processing shall start in not less than 1 second(s).
 3. Tasks that are executed by operator's commands shall include the following:
 - a. Acknowledge Alarms: Used to acknowledge that the operator has observed the alarm message.
 - b. Place Zone in Access: Used to remotely disable intrusion alarm circuits emanating from a specific zone. System shall be structured so that console operator cannot disable tamper circuits.
 - c. Place Zone in Secure: Used to remotely activate intrusion alarm circuits emanating from a specific zone.
 - d. System Test: Allows the operator to initiate a system-wide operational test.
 - e. Zone Test: Allows the operator to initiate an operational test for a specific zone.
 - f. Print reports.
 - g. Change Operator: Used for changing operators.
 - h. Security Lighting Controls: Allows the operator to remotely turn on/off security lights.
 - i. Display Graphics: Used to display any graphic displays implemented in the system. Graphic displays shall be completed within 20 seconds from time of operator command.
 - j. Run system tests.
 - k. Generate and format reports.
 - l. Request help with the system operation.
 - 1) Include in main menus.
 - 2) Provide unique, descriptive, context-sensitive help for selections and functions with the press of one function key.
 - 3) Provide navigation to specific topic from within the first help window.
 - 4) Help shall be accessible outside the applications program.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- m. Entry-Control Commands:
- 1) Lock (secure) or unlock (open) each controlled entry and exit up to four times a day through time-zone programming.
 - 2) Arm or disarm each monitored input up to four times a day through time-zone programming.
 - 3) Enable or disable readers or keypads up to twice a day through time-zone programming.
 - 4) Enable or disable cards or codes up to four times per day per entry point through access-level programming.
4. Command Input Errors: Show operator input assistance when a command cannot be executed because of operator input errors. Assistance screen shall use plain-language words and phrases to explain why the command cannot be executed. Error responses that require an operator to look up a code in a manual or other document are not acceptable. Conditions causing operator assistance messages include the following:
- a. Command entered is incorrect or incomplete.
 - b. Operator is restricted from using that command.
 - c. Command addresses a point that is disabled or out of service.
 - d. Command addresses a point that does not exist.
 - e. Command is outside the system's capacity.
- N. Alarms:
1. System Setup:
 - a. Assign manual and automatic responses to incoming point status change or alarms.
 - b. Automatically respond to input with a link to other inputs, outputs, operator-response plans, unique sound with use of WAV files, and maps or images that graphically represent the point location.
 - c. 60-character message field for each alarm.
 - d. Operator-response-action messages shall allow message length of at least 65,000 characters, with database storage capacity of up to 32,000 messages. Setup shall assign messages to access points, zones, sensors, and other alarm originating devices.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- e. Secondary messages shall be assignable by the operator for printing to provide further information and shall be editable by the operator.
 - f. Allow 25 secondary messages with a field of 4 lines of 60 characters each.
 - g. Store the most recent 1000 alarms for recall by the operator using the report generator.
2. Software Tamper:
- a. Annunciate a tamper alarm when unauthorized changes to system database files are attempted. Three consecutive unsuccessful attempts to log onto system shall generate a software tamper alarm.
 - b. Annunciate a software tamper alarm when an operator or other individual makes three consecutive unsuccessful attempts to invoke functions beyond their authorization level.
 - c. Maintain a transcript file of the last 5000 commands entered at each Central Station to serve as an audit trail. System shall not allow write access to system transcript files by any person, regardless of their authorization level.
 - d. Allow only acknowledgment of software tamper alarms.
3. Read access to system transcript files shall be reserved for operators with the highest password authorization level available in system.
4. Animated Response Graphics: Highlight alarms with flashing icons on graphic maps; display and constantly update the current status of alarm inputs and outputs in real time through animated icons.
5. Multimedia Alarm Annunciation: WAV files to be associated with alarm events for audio annunciation or instructions.
6. Alarm Handling: Each input may be configured so that an alarm cannot be cleared unless it has returned to normal, with options of requiring the operator to enter a comment about disposition of alarm. Allow operator to silence alarm sound when alarm is acknowledged.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

7. Alarm Automation Interface: High-level interface to Central Station alarm automation software systems. Allows input alarms to be passed to and handled by automation systems in same manner as burglar alarms, using an RS-232 ASCII interface.
8. CCTV Alarm Interface: Allow commands to be sent to CCTV systems during alarms (or input change of state) through serial ports.
9. Camera Control: Provides operator ability to select and control cameras from graphic maps.
- O. Alarm Monitoring: Monitor sensors, Controllers, and DTS circuits and notify operators of an alarm condition. Display higher-priority alarms first and, within alarm priorities, display the oldest unacknowledged alarm first. Operator acknowledgment of one alarm shall not be considered acknowledgment of other alarms nor shall it inhibit reporting of subsequent alarms.
 1. Displayed alarm data shall include type of alarm, location of alarm, and secondary alarm messages.
 2. Printed alarm data shall include type of alarm, location of alarm, date and time (to nearest second) of occurrence, and operator responses.
 3. Maps shall automatically display the alarm condition for each input assigned to that map if that option is selected for that input location.
 4. Alarms initiate a status of "pending" and require the following two handling steps by operators:
 - a. First Operator Step: "Acknowledged." This action shall silence sounds associated with the alarm. The alarm remains in the system "Acknowledged" but "Un-Resolved."
 - b. Second Operator Step: Operators enter the resolution or operator comment, giving the disposition of the alarm event. The alarm shall then clear.
 5. Each workstation shall display the total pending alarms and total unresolved alarms.
 6. Each alarm point shall be programmable to disallow the resolution of alarms until the alarm point has returned to its normal state.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

7. Alarms shall transmit to Central Station in real time, except for allowing connection time for dial-up locations.
8. Alarms shall be displayed and managed from a minimum of four different windows.
 - a. Input Status Window: Overlay status icon with a large red blinking icon. Selecting the icon will acknowledge the alarm.
 - b. History Log Transaction Window: Display name, time, and date in red text. Selecting red text will acknowledge the alarm.
 - c. Alarm Log Transaction Window: Display name, time, and date in red. Selecting red text will acknowledge the alarm.
 - d. Graphic Map Display: Display a steady colored icon representing each alarm input location. Change icon to flashing red when the alarm occurs. Change icon from flashing red to steady red when the alarm is acknowledged.
9. Once an alarm is acknowledged, the operator shall be prompted to enter comments about the nature of the alarm and actions taken. Operator's comments may be manually entered or selected from a programmed predefined list, or a combination of both.
10. For locations where there are regular alarm occurrences, provide programmed comments. Selecting that comment shall clear the alarm.
11. The time and name of the operator who acknowledged and resolved the alarm shall be recorded in the database.
12. Identical alarms from same alarm point shall be acknowledged at same time the operator acknowledges the first alarm. Identical alarms shall be resolved when the first alarm is resolved.
13. Alarm functions shall have priority over downloading, retrieving, and updating database from workstations and Controllers.
14. When a reader-controlled output (relay) is opened, the corresponding alarm point shall be automatically bypassed.
- P. Monitor Display: Display text and graphic maps that include zone status integrated into the display. Colors are used for the various components and current data. Colors shall be uniform throughout the system.
 1. Color Code:

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- a. FLASHING RED: Alerts operator that a zone has gone into an alarm or that primary power has failed.
 - b. STEADY RED: Alerts operator that a zone is in alarm and alarm has been acknowledged.
 - c. YELLOW: Advises operator that a zone is in access.
 - d. GREEN: Indicates that a zone is secure, and that power is on.
2. Graphics:
- a. Support 32,000 graphic display maps and allow import of maps from a minimum of 16 standard formats from another drawing or graphics program.
 - b. Allow I/O to be placed on graphic maps by the drag-and-drop method.
 - c. Operators shall be able to view the inputs, outputs, and the point's name by moving the mouse cursor over the point on graphic map.
 - d. Inputs or outputs may be placed on multiple graphic maps. The operator shall be able to toggle to view graphic map associated with inputs or outputs.
 - e. Each graphic map shall have a display-order sequence number associated with it to provide a predetermined order when toggled to different views.
 - f. Camera icons shall have the ability to be placed on graphic maps that, when selected by an operator, will open a video window, display the camera associated with that icon, and provide pan-tilt-zoom control.
 - g. Input, output, or camera placed on a map shall allow the ability to arm or bypass an input, open or secure an output, or control the pan-tilt-zoom function of the selected camera.
- Q. System test software enables operators to initiate a test of the entire system or of a particular portion of the system.
1. Test Report: The results of each test shall be stored for future display or printout. The report shall document the operational status of system components.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- R. Report Generator Software: Include commands to generate reports for displaying, printing, and storing on disk and tape. Reports shall be stored by type, date, and time. Report printing shall be the lowest priority activity. Report generation mode shall be operator selectable but set up initially as periodic, automatic, or on request. Include time and date printed and the name of operator generating the report. Report formats may be configured by operators.
1. Automatic Printing: Setup shall specify, modify, or inhibit the report to be generated; the time the initial report is to be generated; the time interval between reports; the end of period; and the default printer.
 2. Printing on Requests: An operator may request a printout of any report.
 3. Alarm Reports: Reporting shall be automatic as initially set up. Include alarms recorded by system over the selected time and information about the type of alarm [(such as door alarm, intrusion alarm, tamper alarm, etc.)], the type of sensor, the location, the time, and the action taken.
 4. Access and Secure Reports: Document zones placed in access, the time placed in access, and the time placed in secure mode.
 5. Custom Reports: Reports tailored to exact requirements of who, what, when, and where. As an option, custom report formats may be stored for future printing.
 6. Automatic History Reports: Named, saved, and scheduled for automatic generation.
 7. Cardholder Reports: Include data, or selected parts of the data, as well as the ability to be sorted by name, card number, imprinted number, or by any of the user-defined fields.
 8. Cardholder by Reader Reports: Based on who has access to a specific reader or group of readers by selecting the readers from a list.
 9. Cardholder by Access-Level Reports: Display everyone that has been assigned to the specified access level.
 10. Who Is In (Muster) Report:

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- a. Emergency Muster Report: One click operation on toolbar launches report.
 - b. Cardholder Report. Contain a count of persons that are "In" at a selected Location and a count with detailed listing of name, date, and time of last use, sorted by the last reader used or by the group assignment.
11. Panel Labels Reports: Printout of control-panel field documentation including the actual location of equipment, programming parameters, and wiring identification. Maintain system installation data within system database so that they are available on-site at all times.
 12. Activity and Alarm On-Line Printing: Activity printers for use at workstations; prints all events or alarms only.
 13. History Reports: Custom reports that allows the operator to select any date, time, event type, device, output, input, operator, Location, name, or cardholder to be included or excluded from the report.
 - a. Initially store history on the hard disk of the host PC.
 - b. Permit viewing of the history on workstations or print history to any system printer.
 - c. The report shall be definable by a range of dates and times with the ability to have a daily start and stop time over a given date range.
 - d. Each report shall depict the date, time, event type, event description, device, or I/O name, cardholder group assignment, and cardholder name or code number.
 - e. Each line of a printed report shall be numbered to ensure that the integrity of the report has not been compromised.
 - f. Total number of lines of the report shall be given at the end of the report. If the report is run for a single event such as "Alarms," the total shall reflect how many alarms occurred during that period.
 14. Reports shall have the following four options:
 - a. View on screen.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- b. Print to system printer. Include automatic print spooling and "Print To" options if more than one printer is connected to system.
 - c. "Save to File" with full path statement.
 - d. System shall have the ability to produce a report indicating status of system inputs and outputs or of inputs and outputs that are abnormal, out of time zone, manually overridden, not reporting, or in alarm.
15. Custom Code List Subroutine: Allow the access codes of system to be sorted and printed according to the following criteria:
- a. Active, inactive, or future activate or deactivate.
 - b. Code number, name, or imprinted card number.
 - c. Group, Location, access levels.
 - d. Start and stop code range.
 - e. Codes that have not been used since a selectable number of days.
 - f. In, out, or either status.
 - g. Codes with trace designation.
16. The reports of system database shall allow options so that every data field may be printed.
17. The reports of system database shall be constructed so that the actual position of the printed data shall closely match the position of the data on the data-entry windows.
- S. Anti-Passback:
- 1. System shall have global and local anti-passback features, selectable by Location. System shall support hard and soft anti-passback.
 - 2. Hard Anti-Passback: Once a credential holder is granted access through a reader with one type of designation (IN or OUT), the credential holder may not pass through that type of reader designation until the credential holder passes through a reader of opposite designation.
 - 3. Soft Anti-Passback: Should a violation of the proper IN or OUT sequence occur, access shall be granted, but a unique alarm shall be transmitted to the control station, reporting the credential holder

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

and the door involved in the violation. A separate report may be run on this event.

4. Timed Anti-Passback: A Controller capability that prevents an access code from being used twice at the same device (door) within a user-defined amount of time.
5. Provide four separate zones per Location that can operate without requiring interaction with the host PC (done at Controller). Each reader shall be assignable to one or all four anti-passback zones. In addition, each anti-passback reader can be further designated as "Hard," "Soft," or "Timed" in each of the four anti-passback zones. The four anti-passback zones shall operate independently.
6. The anti-passback schemes shall be definable for each individual door.
7. The Master Access Level shall override anti-passback.
8. System shall have the ability to forgive (or reset) an individual credential holder or the entire credential holder population anti-passback status to a neutral status.

T. Visitor Assignment:

1. Provide for and allow an operator to be restricted to only working with visitors. The visitor badging subsystem shall assign credentials and enroll visitors. Allow only access levels that have been designated as approved for visitors.
2. Provide an automated log of visitor name, time and doors accessed, and whom visitor contacted.
3. Allow a visitor designation to be assigned to a credential holder.
4. PACS shall be able to restrict the access levels that may be assigned to credentials that are issued to visitors.
5. Allow operator to recall visitors' credential holder file once a visitor is enrolled in the system.
6. The operator may designate any reader as one that deactivates the credential after use at that reader. The history log shall show the return of the credential.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

7. System shall have the ability to use the visitor designation in searches and reports. Reports shall be able to print all or any visitor activity.
- U. Training Software: Enables operators to practice system operation including alarm acknowledgment, alarm assessment, response force deployment, and response force communications. System shall continue normal operation during training exercises and shall terminate exercises when an alarm signal is received at the console.
- V. Entry-Control Enrollment Software: Database management functions that allow operators to add, delete, and modify access data as needed.
 1. The enrollment station shall not have alarm response or acknowledgment functions.
 2. Provide multiple, password-protected access levels. Database management and modification functions shall require a higher operator access level than personnel enrollment functions.
 3. The program shall provide means to disable the enrollment station when it is unattended to prevent unauthorized use.
 4. The program shall provide a method to enter personnel identifying information into the entry-control database files through enrollment stations. In the case of personnel identity verification subsystems, this shall include biometric data. Allow entry of personnel identifying information into the system database using menu selections and data fields. The data field names shall be customized during setup to suit user and site needs. Personnel identity verification subsystems selected for use with the system shall fully support the enrollment function and shall be compatible with the entry-control database files.
 5. Cardholder Data: Provide 99 user-defined fields. System shall have the ability to run searches and reports using any combination of these fields. Each user-defined field shall be configurable, using any combination of the following features:
 - a. MASK: Determines a specific format that data must comply with.
 - b. REQUIRED: Operator is required to enter data into field before saving.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- c. UNIQUE: Data entered must be unique.
- d. DEACTIVATE DATE: Data entered will be evaluated as an additional deactivate date for all cards assigned to this cardholder.
- e. NAME ID: Data entered will be considered a unique ID for the cardholder.
- 6. Personnel Search Engine: A report generator with capabilities such as search by last name, first name, group, or any predetermined user-defined data field; by codes not used in definable number of days; by skills; or by seven other methods.
- 7. Multiple Deactivate Dates for Cards: User-defined fields to be configured as additional stop dates to deactivate any cards assigned to the cardholder.
- 8. Batch card printing.
- 9. Default card data can be programmed to speed data entry for sites where most card data are similar.
- 10. Enhanced ACSII File Import Utility: Allows the importing of cardholder data and images.
- W. System Redundancy & High Availability: The system shall provide multiple levels of communications redundancy and failover for all PACS hosted controllers, digital video recorders, and client workstations. The PACS shall be capable of automatically re-routing communications to alternate computers across the system without operator intervention.
 - 1. PACS system configuration with a single application/ database server shall provide at a minimum the following redundancy and failover capability:
 - a. The PACS shall provide communications redundancy and failover for network-attached devices. Each network attached device shall have one or more alternative communication sever(s) that can provide hosting in case of primary communications server failure.
 - b. In case of primary communications server failure, the system shall automatically re-route network-attached devices to their designated backup communications servers to allow continuous

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

system operations without loss of alarm and event transaction processing during failover.

- c. Network-attached devices which transition to backup communications servers, shall be able to be redirected back to their default primary servers once the primary communications servers have been restored.

2. PACS system configuration with multiple regional application/database servers shall provide at a minimum the following redundancy and failover capability:

- a) The PACS shall support the same level of communications redundancy and failover for network-attached devices per regional application/database server, allowable to span across regional application/database servers in the event of a regional application/database server failure.
- b) In case of a regional application/database server failure, client workstations shall be able to failover to their designated backup regional application/database server to allow continuous system operations.
- c) In case of a regional application/database server failure, upon server restoration, the ISMS shall automatically update and synchronize the regional application/database server.
- d) Client workstations which transition to a backup regional application/database server, shall be able to be redirected back to their default regional application/database server once the regional application/database server functions have been restored.

2.4 SURGE AND TAMPER PROTECTION

- A. Refer to 28 05 00 COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY

2.5 PACS SERVER HARDWARE (NOT USED)

2.6 STANDARD WORKSTATION HARDWARE (NOT USED)

2.7 COMMUNICATIONS WORKSTATION (NOT USED)

2.8 CONTROLLERS

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 13 00 - 33
Physical Access Control System

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- A. Controllers: Intelligent peripheral control unit, complying with UL 294, that stores time, date, valid codes, access levels, and similar data downloaded from the Central Station or workstation for controlling its operation.
- B. Subject to compliance with requirements in this Article, manufacturers may use multipurpose Controllers.
- C. Battery Backup: Sealed, lead acid; sized to provide run time during a power outage of 90 minutes, complying with UL 924.
- D. Alarm Annunciation Controller:
1. The Controller shall automatically restore communication within 10 seconds after an interruption with the field device network [with dc line supervision on each of its alarm inputs].
 - a. Inputs: Monitor dry contacts for changes of state that reflect alarm conditions. Provides at least eight alarm inputs, which are suitable for wiring as normally open or normally closed contacts for alarm conditions.
 - b. Alarm-Line Supervision:
 - 1) Supervise the alarm lines by monitoring each circuit for changes or disturbances in the signal [, and for conditions as described in UL 1076 for line security equipment] [by monitoring for abnormal open, grounded, or shorted conditions] using dc change measurements. System shall initiate an alarm in response to an abnormal current, which is a dc change of [5] [10] percent or more for longer than 500 ms.
 - 2) Transmit alarm-line-supervision alarm to the Central Station during the next interrogation cycle after the abnormal current condition.
 - c. Outputs: Managed by Central Station software.
 2. Auxiliary Equipment Power: A GFI service outlet inside the Controller enclosure.
- E. Entry-Control Controller:
1. Function: Provide local entry-control functions including one- and two-way communications with access-control devices such as card readers, keypads, biometric personal identity verification devices,

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- door strikes, magnetic latches, gate and door operators, and exit pushbuttons.
- a. Operate as a stand-alone portal Controller using the downloaded database during periods of communication loss between the Controller and the field-device network.
 - b. Accept information generated by the entry-control devices; automatically process this information to determine valid identification of the individual present at the portal:
 - 1) On authentication of the credentials or information presented, check privileges of the identified individual, allowing only those actions granted as privileges.
 - 2) Privileges shall include, but not be limited to, time of day control, day of week control, group control, and visitor escort control.
 - c. Maintain a date-, time-, and Location-stamped record of each transaction. A transaction is defined as any successful or unsuccessful attempt to gain access through a controlled portal by the presentation of credentials or other identifying information.
2. Inputs:
- a. Data from entry-control devices; use this input to change modes between access and secure.
 - b. Database downloads and updates from the Central Station that include enrollment and privilege information.
3. Outputs:
- a. Indicate success or failure of attempts to use entry-control devices and make comparisons of presented information with stored identification information.
 - b. Grant or deny entry by sending control signals to portal-control devices [and mask intrusion alarm annunciation from sensors stimulated by authorized entries].
 - c. Maintain a date-, time-, and Location-stamped record of each transaction and transmit transaction records to the Central Station.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- d. Door Prop Alarm: If a portal is held open for longer than [20 seconds] [time listed in a schedule], alarm sounds.
- 4. With power supplies sufficient to power at voltage and frequency required for field devices and portal-control devices.
- 5. Data Line Problems: For periods of loss of communications with Central Station, or when data transmission is degraded and generating continuous checksum errors, the Controller shall continue to control entry by accepting identifying information, making authentication decisions, checking privileges, and controlling portal-control devices.
 - a. Store up to [1000] transactions during periods of communication loss between the Controller and access-control devices for subsequent upload to the Central Station on restoration of communication.
- 6. Controller Power: NFPA 70, Class II power supply transformer, with 12- or 24-V ac secondary, backup battery and charger.
 - a. Backup Battery: Premium, valve-regulated, recombinant-sealed, lead-calcium battery; spill proof; with a full 1-year warranty and a pro rata 19-year warranty. With single-stage, constant-voltage-current, limited battery charger, comply with battery manufacturer's written instructions for battery terminal voltage and charging current recommendations for maximum battery life.
 - b. Backup Battery: Valve-regulated, recombinant-sealed, lead-acid battery; spill proof. With single-stage, constant-voltage-current, limited battery charger, comply with battery manufacturer's written instructions for battery terminal voltage and charging current recommendations for maximum battery life.
 - c. Backup Power Supply Capacity: [5] [90] minutes of battery supply. Submit battery and charger calculations.
 - d. Power Monitoring: Provide manual dynamic battery load test, initiated and monitored at the control center; with automatic disconnection of the Controller when battery voltage drops below Controller limits. Report by using local Controller-mounted LEDs and by communicating status to Central Station. Indicate normal

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

power on and battery charger on trickle charge. Indicate and report the following:

- 1) Trouble Alarm: Normal power off load assumed by battery.
- 2) Trouble Alarm: Low battery.
- 3) Alarm: Power off.

2.9 PIV MIDDLEWARE (NOT USED)

2.10 CARD READERS

- A. Power: Card reader shall be powered from its associated Controller, including its standby power source.
- B. Response Time: Card reader shall respond to passage requests by generating a signal that is sent to the Controller. Response time shall be 800 ms or less, from the time the card reader finishes reading the credential card until a response signal is generated.
- C. Enclosure: Suitable for surface, semi flush, or pedestal mounting. Mounting types shall additionally be suitable for installation in the following locations:
 1. Indoors, controlled environment.
 2. Indoors, uncontrolled environment.
 3. Outdoors, with built-in heaters or other cold-weather equipment to extend the operating temperature range as needed for operation at the site.
- D. Display: LED or other type of visual indicator display shall provide visual [and audible] status indications and user prompts. Indicate power on/off, whether user passage requests have been accepted or rejected, and whether the door is locked or unlocked.
- E. Shall be utilized for controlling the locking hardware on a door and allows for reporting back to the main control panel with the time/date the door was accessed, the name of the person accessing the point of entry, and its location.
- F. Will be fully programmable and addressable, locally and remotely, and hardwired to the system.
- G. Shall be individually home run to the main panel.
- H. Shall be installed in a manner that they comply with:
 1. The Uniform Federal Accessibility Standards (UFAS)

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

2. The Americans with Disabilities Act (ADA)
3. The ADA Standards for Accessible Design
- I. Shall support a variety of card readers that must encompass a wide functional range. The PACS may combine any of the card readers described below for installations requiring multiple types of card reader capability (i.e., card only, card and/or PIN, card and/or biometrics, card and/or pin and/or biometrics, supervised inputs, etc.). These card readers shall be available in the approved technology to meet FIPS 201, and is ISO 14443 A or B, ISO/IEC 7816 compliant. The reader output can be Wiegand, RS-22, 485 or TCP/IP.
- J. Shall be housed in an aluminum bezel with a wide lead-in for easy card entry.
- K. Shall contain read head electronics, and a sender to encode digital door control signals.
- L. LEDs shall be utilized to indicate card reader status and access status.
- M. Shall be able to support a user defined downloadable off-line mode of operation (e.g., locked, unlocked), which will go in effect during loss of communication with the main control panel.
- N. Shall provide audible feedback to indicate access granted/denied decisions. Upon a card swipe, two audible tones or beeps shall indicate access granted and three tones or beeps shall indicate access denied. All keypad buttons shall provide tactile audible feedback.
- O. Shall have a minimum of two programmable inputs and two programmable outputs.
- P. All card readers that utilize keypad controls along with a reader and shall meet the following specifications:
 1. Entry control keypads shall use a unique combination of alphanumeric and other symbols as an identifier. Keypads shall contain an integral alphanumeric/special symbols keyboard with symbols arranged in ascending ASCII code ordinal sequence. Communications protocol shall be compatible with the local processor.
- Q. Shall include a Light Emitting Diode (LED) or other type of visual indicator display and provide visual or visual and audible status

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

indications and user prompts. The display shall indicate power on/off, and whether user passage requests have been accepted or rejected. The design of the keypad display or keypad enclosure shall limit the maximum horizontal and vertical viewing angles of the keypad. The maximum horizontal viewing angle shall be plus and minus five (5) degrees or less off a vertical plane perpendicular to the plane of the face of the keypad display. The maximum vertical viewing angle shall be plus and minus 15 degrees or less off a horizontal plane perpendicular to the plane of the face of the keypad display.

1. Shall respond to passage requests by generating a signal to the local processor. The response time shall be 800 milliseconds or less from the time the last alphanumeric symbol is entered until a response signal is generated.
2. Shall be powered from the source as designed and shall not dissipate more than 150 Watts.
3. Shall be suitable for surface, semi-flush, pedestal, or weatherproof mounting as required.
4. Shall provide a means for users to indicate a duress situation by entering a special code.

R. PIV Contact Card Reader

1. Application Protocol Data Unit (APDU) Support: At a minimum, the contact interface shall support all card commands for contact-based access specified in Section 7, End-point PIV Card Application Card Command Interface of SP 800-73-1, Interfaces for Personal Identity Verification.
2. Buffer Size: The reader must contain a buffer large enough to receive the maximum size frame permitted by International Organization for Standardization International Electrotechnical Commission (ISO/IEC) 7816-3:1997, Section 9.4.
3. Programming Voltage: PIV Readers shall not generate a Programming Voltage.
4. Support for Operating Class: PIV Readers shall support cards with Class A Vccs as defined in ISO/IEC 7816-3:1997 and ISO/IEC 7816-3:1997/Amd 1:2002.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

5. Retrieval Time: Retrieval time¹ for 12.5 kilobytes (KB) of data through the contact interface of the reader shall not exceed 2.0 seconds.
 6. Transmission Protocol: The PIV Reader shall support both the character-based T=0 protocol and block-based T=1 protocol as defined in ISO/IEC 7816-3:1997.
 7. Support for PPS Procedure: The reader shall support Protocol and Parameters Selection (PPS) procedure by having the ability to read character TA1 of the Answer to Reset (ATR) sent by the card as defined in ISO/IEC 7816-3:1997.
- S. Contactless Smart Cards and Readers
1. Smart card readers shall read credential cards whose characteristics of size and technology meet those defined by ISO/IEC 7816, 14443, 15693.
 2. The readers shall have "flash" download capability to accommodate card format changes.
 3. The card reader shall have the capability of reading the card data and transmitting the data to the main monitoring panel.
 4. The card reader shall be contactless and meet or exceed the following technical characteristics:
 - a. Data Output Formats: FIPS 201 low outputs the FASC-N in an assortment of Wiegand bit formats from 40 - 200 bits. FIPS 201 medium outputs a combination FASC-N and HMAC in an assortment of Wiegand bit formats from 32 - 232 bits. All Wiegand formats or the upgradeability from Low to Medium Levels can be field configured with the use of a command card.
 - b. FIPS 201 readers shall be able to read, but not be limited to, DESfire and iCLASS cards.
 - c. Reader range shall comply with ISO standards 7816, 14443, and 15693, and also take into consideration conditions, are at a minimum 1" to 2" (2.5 - 5 cm).

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- d. APDU Support: At a minimum, the contactless interface shall support all card commands for contactless based access specified in Section 7, End-point PIV Card Application Card Command Interface of SP 800-73-1, Interfaces for Personal Identity Verification.
- e. Buffer Size: The reader shall contain a buffer large enough to receive the maximum size frame permitted by ISO/IEC 7816-3, Section 9.4.
- f. ISO 14443 Support: The PIV Reader shall support parts (1 through 4) of ISO/IEC 14443 as amended in the References of this publication.
- g. Type A and B Communication Signal Interfaces: The contactless interface of the reader shall support both the Type A and Type B communication signal interfaces as defined in ISO/IEC 14443-2:2001.
- h. Type A and B Initialization and Anti-Collision The contactless interface of the reader shall support both Type A and Type B initialization and anti-collision methods as defined in ISO/IEC 14443-3:2001.
- i. Type A and B Transmission Protocols: The contactless interface of the reader shall support both Type A and Type B transmission protocols as defined in ISO/IEC 14443-4:2001.
- j. Retrieval Time: Retrieval time for 4 KB of data through the contactless interface of the reader shall not exceed 2.0 seconds.
- k. Transmission Speeds: The contactless interface of the reader shall support bitrates of fc/128 (~106 kbits/s), fc/64 (~212 kbits/s), and configurable to allow activation/deactivation.
- l. Readability Range: The reader shall not be able to read PIV card more than 10cm(4inch) from the reader

2.11 BIOMETRIC IDENTITY VERIFICATION EQUIPMENT

- A. Shall be FIPS 201 and NIST SP 800-76 compliant.
- B. Shall utilize hand/palm, fingerprint, retinal, facial image, or voice verification and could be utilized as secondary authentication in conjunction with card readers in high security area as defined by the

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- VA. (Note: VA policy requires that the use of biometric measurements is limited to secondary authentication in high or medium security applications).
- C. Shall be programmable, addressable, and hardwired directly to the main control panel and individually home run to the main control panel.
 - D. Shall be installed in a manner that they comply with:
 - 1. The Uniform Federal Accessibility Standards (UFAS)
 - 2. The Americans with Disabilities Act (ADA)
 - 3. The ADA Standards for Accessible Design
 - E. Shall include a means to construct individual templates or profiles based upon measurements taken from the person to be enrolled. This template shall be stored as part of the System Reference Database Files. The stored template shall be used as a comparative base by the personnel identity verification equipment to generate appropriate signals to the associated local processors.
 - F. Shall interface with PACS and SMS and provide the employee's name, contact information, and point of access.
 - G. Shall allow for surface, flush, or pedestal mounting.
 - H. Shall have communications protocol in place that shall allow for communications with the SMS.
 - I. Shall determine when multiple attempts were made for verification and shall automatically prompt the user for additional attempts up to a maximum of three tries. After a third failed attempt the unit shall generate an entry control alarm. This alarm will report to the SMS and the CCTV system. The camera viewpoint for where the alarm was generated shall automatically be called up onto a monitor and be recorded via the recording equipment. An alarm within the SMS shall also be generated recording, at a minimum, the date, time, and attempted point of entry.
 - J. Hand/Palm Geometry Verification:
 - 1. Shall utilize unique human hand measurements to identify authorized, enrolled personnel.
 - 2. During the scan process the hand geometry device, which shall allow the user's hand to remain in full view during the scanning process,

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- shall a three (3) dimensional measurement of the user's hand be identifying its size and shape.
3. This scan process shall start automatically once the user's hand is positioned. The hand geometry device shall be able to use either left or right hands for enrollment and verification.
 4. Shall include an LED or other type of visual indicator display and provide visual or visual and audible status indications and user prompts. The display shall indicate power on/off, and whether user passage requests have been accepted or rejected.
 5. Shall only be updated at the unit itself and automatic updates via the SMS shall not be allowed.
 6. Any significant change to the user's hand, scars, loss of digit, or any other change that will alter the three-dimension view of the hand shall require an update to the unit and SMS.
 7. Shall provide an enrollment, recognition, and code/credential verification mode. The enrollment mode shall create a hand template for new personnel and enter the template into the entry control database file created for that person. Template information shall be compatible with the system application software. The operating mode shall be selectable by the system manager/operator from the central processor. When operating in recognition mode, the hand geometry device shall allow passage when the hand scan data from the verification attempt matches a hand geometry template stored in the database files. When operating in code/credential verification mode, the hand geometry device shall allow passage when the hand scan data from the verification attempt matches the hand geometry template associated with the identification code entered into a keypad; or matches the hand geometry template associated with credential card data read by a card reader.

K. Fingerprint Verification:

1. Shall use a unique human fingerprint pattern to identify authorized, enrolled personnel.
2. Shall allow the user's hand to remain in full view during the scanning process, shall incorporate positive measures to establish

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 13 00 - 43
Physical Access Control System

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- that the hand or fingers being scanned by the device belong to a living human being.
3. Shall provide an optical or other type of scan of the user's fingers. The fingerprint verification scanner shall automatically initiate the scan process provided the user's fingers are positioned.
 4. LED or other type of visual indicator displays shall provide a visual or visual and audible status indication and enrollee prompts. The display shall indicate power on/off, and whether user passage requests have been accepted or rejected.
 5. Any significant change to the user's finger such as scars, loss of digit, or any other change that will alter the fingerprint shall require an update to the unit and SMS.
 6. Shall provide an adjustable acceptance tolerance or template match criteria under system manager/operator control.
 7. Shall respond to passage requests by generating signals to the local processor. The verification time shall be 2.0 seconds or less from the moment the fingerprint analysis scanner initiates the scan process until the fingerprint analysis scanner generates a response signal.
 8. Shall:
 - a. Provide an enrollment mode, recognition mode, and code/credential verification mode. The enrollment mode shall create a fingerprint template for new personnel and enter the template into the system database file created for that person.
 - b. Template information shall be compatible with the system application software.
 - c. The operating mode shall be selectable by the system manager/operator from the central station.
 9. When operating in recognition mode, the fingerprint analysis scanner shall allow passage when the fingerprint data from the verification attempt matches a fingerprint template stored in the database files.
 10. When operating in code/credential verification mode, the fingerprint analysis scanner shall allow passage when the fingerprint data from

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- the verification attempt matches a fingerprint template associated with the identification code. When entered into a keypad or it matches the fingerprint template associated with credential, the card data will then be recognized by the card reader.
11. Shall store template transactions involving fingerprint scans. The template match scores shall be stored in the matching personnel data file in a format compatible with the system application software and shall be used for report generation.
 12. Shall be unit listed as FIPS 201 Approved product.
- L. Iris Verification:
1. Shall utilize unique patterns within the human eye to identify authorized, enrolled personnel.
 2. Shall use ambient light to capture an image of the iris of the person presenting themselves for identification. The resulting video image shall be compared against a stored template that was captured during the enrollment process.
 3. Shall utilize a threshold for identification. The efficiency and accuracy of the device shall not be adversely affected by enrollees who wear contact lenses or eyeglasses.
 4. Shall provide a means for enrollees to align their eye for identification that does not require facial contact with the device.
 5. Initiation for the scan should be automatic, but push-button could be provided to initiate the scan process. The device shall include adjustments to accommodate differences in enrollee height and mounting height shall be UFAS compliant.
 6. The LED or other type of visual indicator displays shall provide a visual or visual and audible status indication and enrollee prompts. The display shall indicate power on/off, and whether user passage requests have been accepted or rejected.
 7. Verification time for the retinal verification unit shall be no greater than 1.5 seconds from the moment the action is initiated until a response signal has been generated.
 8. Shall provide an enrollment mode, recognition mode, and code/credential verification mode:

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- a. The enrollment mode shall create an iris template for new personnel and enter the template into the system database file created for that person. Template information shall be compatible with the system application software.
 - b. When operating in recognition mode, the retinal verification unit shall allow passage when the retinal verification data from the verification attempt matches an iris template stored in the database files.
 - c. When operating in code/credential verification mode, the iris scanner shall allow passage when the retinal verification data from the verification attempt matches the retinal verification template. This will occur when the associated information matches the identification code entered into a keypad or matches the retinal verification template associated with the credential card data when recognized by a card reader.
9. Shall store template transactions involving retinal verifications. The template match scores shall be stored in the matching personnel data file in a file format compatible with the system application software and shall be used for report generation.
- M. Voice Verification:
1. Shall utilize unique patterns within the human speech pattern to identify authorized, enrolled personnel.
 2. Shall digitize a profile of a person's speech to produce a stored model voice print, or template. Users shall record their full names utilizing their natural voice tendencies. This process shall be initiated by a push to talk button on the voice verification device.
 3. Shall utilize a threshold for identification. The efficiency and accuracy of the device shall not be adversely affected by enrollees who have a speech impediment.
 4. Shall provide a means for enrollees to align their voice for identification that does not require contact with the device.
 5. The LED or other type of visual indicator displays shall provide a visual or visual and audible status indication and enrollee prompts.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

The display shall indicate power on/off, and whether user passage requests have been accepted or rejected.

6. Verification time for the voice verification unit shall be no greater than 1.5 seconds from the moment the action is initiated until a response signal has been generated.
7. Shall provide an enrollment mode, recognition mode, and code/credential verification mode:
 - a. The enrollment mode shall create a voice template for new personnel and enter the template into the system database file created for that person. Template information shall be compatible with the system application software.
 - b. When operating in recognition mode, the voice verification unit shall allow passage when the voice verification data from the verification attempt matches a voice template stored in the database files.
 - c. When operating in code/credential verification mode, the voice verifier shall allow passage when the voice verification data from the verification attempt matches the voice verification template. This will occur when the associated information of the identification code entered into a keypad matches the voice verification template associated with a credential card data is recognized by a card reader.
8. Shall store template transactions involving voice verifications. The template match scores shall be stored in the matching personnel data file in a file format compatible with the system application software, MPEG or equivalent, and shall be used for report generation.

2.11 KEYPADS

- A. Designed for use with unique combinations of alphanumeric and other symbols as an Identifier. Keys of keypads shall contain an integral alphanumeric/special symbol keyboard with symbols arranged in [ascending ASCII-code ordinal sequence] [random scrambled order]. Communications protocol shall be compatible with Controller.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

1. Keypad display or enclosure shall limit viewing angles of the keypad as follows:
 - a. Maximum Horizontal Viewing Angle: 5 degrees or less off in either direction of a vertical plane perpendicular to the plane of the face of the keypad display.
 - b. Maximum Vertical Viewing Angle: 15 degrees or less off in either direction of a horizontal plane perpendicular to the plane of the face of the keypad display.
2. Duress Codes: Provide duress situation indication by entering a special code.

2.12 CREDENTIAL CARDS

- A. Personal Identity Verification (PIV) credential cards shall comply to Federal Information Processing Standards Publication (FIPS) 201.

N/A

2.13 SYSTEM SENSORS AND RELATED EQUIPMENT

- A. The PACS (Physical Access Control System) and related Equipment provided by the Contractor shall meet or exceed the following performer specifications:
- B. Request to Exit Detectors:
 1. Passive Infrared Request to Exit Motion Detector (REX PIR) (1) The Contractor shall provide a surface mounted motion detector to signal the physical access control system request to exit input. The motion detector shall be a passive infrared sensor designed for wall or ceiling mounting 2134 to 4572 mm (7 to 15 ft) height. The detector shall provide two (2) form "C" (SPDT) relays rated one (1) Amp. @ 30 VDC for DC resistiveloads. The detectors relays shall be user adjustable with a latch time from 1-60 seconds. The detector shall also include a selectable relay reset mode to follow the timer or absence of motion. The detection pattern shall be adjustable plus or minus fourteen (± 14) degrees. The detector shall operate on 12 VDC with approximately 26 mA continuous current draw. The detector shall have an externally visible activation LED. The motion detector shall measure approximately 38 mm H x 158 mm W x 38 mm D (1.5 x 6.25 x 1.5 in). The detector shall be immune to radio frequency interference.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

The detector shall not activate or set-up on critical frequencies in the range 26 to 950 Megahertz using a 50-watt transmitter located 30.5 cm (1 ft) from the unit or attached wiring. The detector shall be available on gray or black enclosures. The color of the housing shall be coordinated with the surrounding surface.

C. Guard tour stations:

N/A

D. Delayed Egress (DE)

N/A

E. Crash Bar:

1. Emergency Exit with Alarm (Panic):

- a. Entry control portals shall include panic bar emergency exit hardware as designed.
- b. Panic bar emergency exit hardware shall provide an alarm shunt signal to the PACS and SMS.
- c. The panic bar shall include a conspicuous warning sign with one (1) inch (2.5 cm) high, red lettering notifying personnel that an alarm will be annunciated if the panic bar is operated.
- d. Operation of the panic bar hardware shall generate an intrusion alarm that reports to both the SMS and Intrusion Detection System. The use of a micro switch installed within the panic bar shall be utilized for this.
- e. The panic bar shall utilize a fully mechanical connection only and shall not depend upon electric power for operation.
- f. The panic bar shall be compatible with mortise or rim mount door hardware and shall operate by retracting the bolt manually by either pressing the panic bar or with a key by-pass. Refer to Section 2.2.I.9 for key-bypass specifications.
- g. Normal Exit:
 - 1) Entry control portals shall include panic bar non-emergency exit hardware as designed.
 - 2) Panic bar non-emergency exit hardware shall be monitored by and report to the SMS.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- 3) Operation of the panic bar hardware shall not generate a locally audible or an intrusion alarm within the IDS.
- 4) When exiting, the panic bar shall depend upon a mechanical connection only. The exterior, non-secure side of the door shall be provided with an electrified thumb latch or lever to provide access after the credential I.D. authentication by the SMS.
- 5) The panic bar shall be compatible with mortise or rim mount door hardware and shall operate by retracting the bolt manually by either pressing the panic bar or with a key bypass. Refer to Section 2.2.I.9 for key-bypass specifications. The strikes/bolts shall include a micro switch to indicate to the system when the bolt is not engaged, or the strike mechanism is unlocked. The signal switches shall report a forced entry to the system in the event the door is left open or accessed without the identification credentials.

F. Key Bypass:

1. Shall be utilized for all doors that have a mortise or rim mounted door hardware.
2. Each door shall be individually keyed with one master key per secured area.
3. Cylinders shall be six (6)-pin and made of brass or equivalent. Keys for the cylinders shall be constructed of solid material and produced and cut by the same distributor. Keys shall not be purchased, cut, and supplied by multiple dealers.
4. All keys shall have a serial number cut into the key. No two serial numbers shall be the same.
5. All keys and cylinders shall be stored in a secure area that is monitored by the Intrusion Detection System.

G. Automatic Door Opener and Closer:

N/A

H. Door Status Indicators:

1. Shall monitor and report door status to the SMS.
2. Door Position Sensor:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- a. Shall provide an open or closed indication for all doors operated on the PACS and report directly to the SMS.
- b. Shall also provide alarm input to the Intrusion Detection System for all doors operated by the PACS and all other doors that require monitoring by the intrusion detection system.
- c. Switches for doors operated by the PACS shall be double pole double throw (DPDT). One side of the switch shall monitor door position and the other side if the switch shall report to the intrusion detection system. For doors with electromagnetic locks a magnetic bonding sensor (MBS) can be used in place of one side of a DPDT switch, in turn allowing for the use of a single pole double throw (SPDT) switch in its place of a DPDT switch.
- d. Switches for doors not operated by the PACS shall be SPDT and report directly to the IDS.
- e. Shall be surface or flush mounted and wide gap with the ability to operate at a maximum distance of up to 2" (5 cm).

2.14 PUSH BUTTON SWITCHES

- A. Push-Button Switches: Momentary-contact back-lighted push buttons, with stainless-steel switch enclosures.
 1. Electrical Ratings:
 - a. Minimum continuous current rating of 10 A at 120 VAC or 5 A at 240 VAC.
 - b. Contacts that will make 720 VA at 60 A and that will break at 720 VA at 10 A.
 2. Enclosures: Flush or surface mounting. Push buttons shall be suitable for flush mounting in the switch enclosures.
 3. Enclosures shall additionally be suitable for installation in the following locations:
 - a. Indoors, controlled environment.
 - b. Indoors, uncontrolled environment.
 - c. Outdoors.
 4. Power: Push-button switches shall be powered from their associated Controller, using dc control.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

2.15 PORTAL CONTROL DEVICES

- A. Shall be used to assist the PACS.
- B. Such devices shall:
 - 1. Provide a means of monitoring the doors status.
 - 2. Allow for exiting a space via either a push button, request to exit, or panic/crash bar.
 - 3. Provide a means of override to the PACS via a keypad or key bypass.
 - 4. Assist door operations utilizing automatic openers and closures.
 - 5. Provide a secondary means of access to a space via a keypad.
- C. Shall be connected to and monitored by the main PACS panel.
- D. Shall be installed in a manner that they comply with:
 - 1. The Uniform Federal Accessibility Standards (UFAS)
 - 2. The Americans with Disabilities Act (ADA)
 - 3. The ADA Standards for Accessible Design
- E. Shall provide a secondary means of physical access control within a secure area.
- F. Push-Button Switches:
 - 1. Shall be momentary contact, back lighted push buttons, and stainless-steel switch enclosures for each push button as shown. Buttons are to be utilized for secondary means of releasing a locking mechanism.
 - a. In an area where a push button is being utilized for remote access of the locking device then no more than two (2) buttons shall operate one door from within one secure space. Buttons will not be wired in series with one other.
 - b. In an area where locally stationed guards control entry to multiple secure points via remote switches. An interface board shall be designed and constructed for only the amount of buttons it shall house. These buttons shall be flush mounted and clearly labeled for ease of use. All buttons shall be connected to the PACS and SMS system for monitoring purposes.
 - c. Shall have double-break silver contacts that will make 720 VA at 60 amperes and break 720 VA at 10 amperes.
- G. Entry Control Devices:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

1. Shall be hardwired to the PACS main control panel and operated by either a card reader or a biometric device via a relay on the main control panel.
2. Shall be fail-safe in the event of power failure to the PACS system.
3. Shall operate at 24 VCD, with the exception of turnstiles and be powered by a separate power supply dedicated to the door control system. Each power supply shall be rated to operate a minimum of two doors simultaneously without error to the system or overload the power supply unit.
4. Shall have a diode or metal-oxide varistor (MOV) to protect the controller and power supply from reverse current surges or back-check.
5. Electric Strikes/Bolts: Shall be:
 - a. Made of heavy-duty construction and tamper resistant design.
 - b. Tested to over one million cycles.
 - c. Rated for a minimum of 1000 lbs. holding strength.
 - d. Utilize an actuating solenoid for the strike/bolt. The solenoid shall move from fully open to fully closed position and back in not more than 500 milliseconds and be rated for continuous duty.
 - e. Utilize a signal switch that will indicate to the system if the strike/bolt is not engaged or is unlocked when it should be secured.
 - f. Flush mounted within the door frame.
6. Electric Mortise Locks: Shall be installed within the door and an electric transfer hinge shall be utilized to allow the wires to be transferred from the door frame to the lock. If utilized with a double door then the lock shall be installed inside the active leaf. Electric Mortise Locks shall:
 - a. These locks shall be provided and installed by the Division 8 "DOOR HARDWARE" Contractor.
 - b. Have integrated Request to Exit switch for new doors receiving physical access control devices.
 - c. Provide integration of the Electric Mortise Locks with the PACS for:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- 1) Lock Power
- 2) Request to Exit switch.

7. Electromagnetic Locks:

vv N/A

8. Turnstiles:

N/A

9. Vehicle Gate Operator:

N/A

2.17 INTERFACES (NOT USED)

2.18 FLOOR SELECT ELEVATOR CONTROL (NOT USED)

2.19 AFTER-HOURS HVAC CONTROL (NOT USED)

2.20 REAL TIME GUARD TOUR (NOT USED)

2.21 VIDEO AND CAMERA CONTROL

A. Control station or designated workstation displays live video from a CCTV source.

1. Control Buttons: On the display window, with separate control buttons to represent Left, Right, Up, Down, Zoom In, Zoom Out, Scan, and a minimum of two custom command auxiliary controls.
2. Provide at least seven icons to represent different types of cameras, with ability to import custom icons. Provide option for display of icons on graphic maps to represent their physical location.
3. Provide the alarm-handling window with a command button that will display the camera associated with the alarm point.

B. Display mouse-selectable icons representing each camera source, to select source to be displayed. For CCTV sources that are connected to a video switcher, control station shall automatically send control commands through a COM port to display the requested camera when the camera icon is selected.

C. Allow cameras with preset positioning to be defined by displaying a different icon for each of the presets. Provide control with Next and Previous buttons to allow operator to cycle quickly through the preset positions.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

PART 3 - EXECUTION

3.1 GENERAL

- A. The Contractor shall install all system components and appurtenances in accordance with the manufacturers' instructions, ANSI C2, and shall furnish all necessary interconnections, services, and adjustments required for a complete and operable system as specified. Control signals, communications, and data transmission lines grounding shall be installed as necessary to preclude ground loops, noise, and surges from affecting system operation. Equipment, materials, installation, workmanship, inspection, and testing shall be in accordance with manufacturers' recommendations and as modified herein.
- B. Consult the manufacturers' installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc., before beginning system installation. Refer to the Riser/Connection diagram for all schematic system installation/termination/wiring data.
- C. All equipment shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place (e.g., sensors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load.

3.2 CURRENT SITE CONDITIONS

- A. The Contractor shall visit the site and verify that site conditions are in agreement with the design package. The Contractor shall report all changes to the site or conditions which will affect performance of the system to the Owner in a report as defined in paragraph Group II Technical Data Package. The Contractor shall not take any corrective action without written permission from the Owner.

3.3 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
- B. Examine roughing-in for LAN and control cable conduit systems to PCs, Controllers, card readers, and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 13 00 - 55
Physical Access Control System

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.4 PREPARATION

- A. Comply with recommendations in SIA CP-01.
- B. Comply with EIA/TIA-606, "Administration Standard for the Telecommunications Infrastructure of Commercial Buildings."
- C. Obtain detailed Project planning forms from manufacturer of access-control system; develop custom forms to suit Project. Fill in all data available from Project plans and specifications and publish as Project planning documents for review and approval.
1. Record setup data for control station and workstations.
 2. For each Location, record setup of Controller features and access requirements.
 3. Propose start and stop times for time zones and holidays and match up access levels for doors.
 4. Set up groups, linking, and list inputs and outputs for each Controller.
 5. Assign action message names and compose messages.
 6. Set up alarms. Establish interlocks between alarms, intruder detection, and video surveillance features.
 7. Prepare and install alarm graphic maps.
 8. Develop user-defined fields.
 9. Develop screen layout formats.
 10. Propose setups for guard tours and key control.
 11. Discuss badge layout options, design badges.
 12. Complete system diagnostics and operation verification.
 13. Prepare a specific plan for system testing, startup, and demonstration.
 14. Develop acceptance test concept and, on approval, develop specifics of the test.
 15. Develop cable and asset management system details, input data from construction documents. Include system schematics and Technical Drawings.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- D. In meetings with Architect and Owner, present Project planning documents and review, adjust, and prepare final setup documents. Use final documents to set up system software.

3.5 CABLING

- A. Comply with NECA 1, "Good Workmanship in Electrical Contracting."
- B. Install cables and wiring according to requirements in Division 28 Section "Conductors and Cables for Electronic Safety and Security."
- D. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use NRTL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.
- E. Install LAN cables using techniques, practices, and methods that are consistent with Category 5E rating of components and that ensure Category 5E performance of completed and linked signal paths, end to end.
- F. Install cables without damaging conductors, shield, or jacket.
- G. Boxes and enclosures containing security system components or cabling, and which are easily accessible to employees or to the public, shall be provided with a lock. Boxes above ceiling level in occupied areas of the building shall not be considered to be accessible. Junction boxes and small device enclosures below ceiling level and easily accessible to employees or the public shall be covered with a suitable cover plate and secured with tamperproof screws.
- H. Install end-of-line resistors at the field device location and not at the Controller or panel location.
- I. Cabling may not be spliced. Cabling serving existing devices that are to be relocated shall be replaced in its entirety if the cable is found to be in disrepair or is not of sufficient length to serve the new location.

3.6 CABLE APPLICATION

- A. Comply with EIA/TIA-569, "Commercial Building Standard for Telecommunications Pathways and Spaces."

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 13 00 - 57
Physical Access Control System

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- B. Cable application requirements are minimum requirements and shall be exceeded if recommended or required by manufacturer of system hardware.
- C. RS-232 Cabling: Install at a maximum distance of 50 feet (15 m).
- D. RS-485 Cabling: Install at a maximum distance of 4000 feet (1220 m).
- E. Card Readers and Keypads:
 - 1. Install number of conductor pairs recommended by manufacturer for the functions specified.
 - 2. Unless manufacturer recommends larger conductors, install No. 22 AWG wire if maximum distance from Controller to the reader is 250 feet (75 m), and install No. 20 AWG wire if maximum distance is 500 feet (150 m).
 - 3. For greater distances, install "extender" or "repeater" modules recommended by manufacturer of the Controller.
 - 4. Install minimum No. 18 AWG shielded cable to readers and keypads that draw 50 mA or more.
- F. Install minimum No. 16 AWG cable from Controller to electrically powered locks. Do not exceed 250 feet (75 m).
- G. Install minimum No. 18 AWG ac power wire from transformer to Controller, with a maximum distance of [25 feet (8 m)].

3.7 GROUNDING

- A. Comply with Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Comply with IEEE 1100, "Power and Grounding Sensitive Electronic Equipment."
- C. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- D. Signal Ground:
 - 1. Terminal: Locate in each equipment room and wiring closet; isolate from power system and equipment grounding.
 - 2. Bus: Mount on wall of main equipment room with standoff insulators.
 - 3. Backbone Cable: Extend from signal ground bus to signal ground terminal in each equipment room and wiring closet.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

3.8 INSTALLATION

- A. System installation shall be in accordance with UL 294, manufacturer and related documents and references, for each type of security subsystem designed, engineered and installed.
- B. Components shall be configured with appropriate "service points" to pinpoint system trouble in less than 30 minutes.
- C. The Contractor shall install all system components including Government furnished equipment, and appurtenances in accordance with the manufacturer's instructions, documentation listed in Sections 1.4 and 1.5 of this documents, and shall furnish all necessary connectors, terminators, interconnections, services, and adjustments required for an operable system.
- D. The PACS will be designed, engineered, installed, and tested to ensure all components are fully compatible as a system and can be integrated with all associated security subsystems, whether the system is a standalone or a network.
- E. For integration purposes, the PACS shall be integrated where appropriate with the following associated security subsystems:
 - 1. CCTV:
 - a. Provide 24-hour coverage of all entry points to the perimeter and agency buildings. As well as all emergency exits utilizing a fixed color camera.
 - b. Be able to monitor, control and record cameras on a 24 hour basis.
 - c. Be programmed automatically call up a camera when an access point is but into an alarm state.
 - d. For additional PACS system requirements as they relate to the CCTV, refer to Section 28 23 00, VIDEO SURVEILLANCE.
 - 2. IDS:
 - a. Be able monitor door control sensors.
 - b. Be able to monitor and control the IDS on a 24 hour basis.
 - c. Be programmed to go into an alarm state when an IDS device is put into an alarm state and notify the operator via an audible alarm.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- d. For additional PACS system requirements as they relate to the IDS, refer to Section 28 16 11, INTRUSION DETECTION SYSTEM.
- 3. Security Access Detection:
 - a. Be able to monitor all objects that have been screened with an x-ray machine and be able to monitor all data acquired by the bomb detection unit.
 - b. For additional PACS system requirements as they relate to the Security Access Detection, refer to Section 28 13 53, SECURITY ACCESS DETECTION.
- 4. EPPS:
 - a. Be programmed to go into an alarm state when an emergency call box or duress alarm/panic device is activated and notify the Physical Access Control System and Database Management of an alarm event.
 - b. For additional PACS requirements as they relate to the EPPS, refer to Section 28 26 00, ELECTRONIC PERSONAL PROTECTION SYSTEM.
- F. Integration with these security subsystems shall be achieved by computer programming or the direct hardwiring of the systems.
- G. For programming purposes refer to the manufacturers requirements for correct system operations. Ensure computers being utilized for system integration meet or exceed the minimum system requirements outlined on the systems software packages.
- H. The Contractor shall visit the site and verify that site conditions are in agreement with the design package. The Contractor shall report all changes to the site or conditions that will affect performance of the system. The Contractor shall not take any corrective action without written permission from the Government.
- I. The Contractor shall visit the site and verify that site conditions are in agreement/compliance with the design package. The Contractor shall report all changes to the site or conditions that will affect performance of the system to the Contracting Officer in the form of a report. The Contractor shall not take any corrective action without written permission received from the Contracting Officer.
- J. Existing Equipment:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 13 00 - 60
Physical Access Control System

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

1. The Contractor shall connect to and utilize existing door equipment, control signal transmission lines, and devices as outlined in the design package. Door equipment and signal lines that are usable in their original configuration without modification may be reused with Contracting Officer approval.
2. The Contractor shall perform a field survey, including testing and inspection of all existing door equipment and signal lines intended to be incorporated into the PACS, and furnish a report to the Contracting Officer as part of the site survey report. For those items considered nonfunctioning, provide (with the report) specification sheets, or written functional requirements to support the findings and the estimated cost to correct the deficiency. As part of the report, the Contractor shall include a schedule for connection to all existing equipment.
3. The Contractor shall make written requests and obtain approval prior to disconnecting any signal lines and equipment and creating equipment downtime. Such work shall proceed only after receiving Contracting Officer approval of these requests. If any device fails after the Contractor has commenced work on that device, signal or control line, the Contractor shall diagnose the failure and perform any necessary corrections to the equipment.
4. The Contractor shall be held responsible for repair costs due to Contractor negligence, abuse, or improper installation of equipment.
5. The Contracting Officer shall be provided a full list of all equipment that is to be removed or replaced by the Contractor, to include description and serial/manufacturer numbers where possible. The Contractor shall dispose of all equipment that has been removed or replaced based upon approval of the Contracting Officer after reviewing the equipment removal list. In all areas where equipment is removed or replaced the Contractor shall repair those areas to match the current existing conditions.

K. Enclosure Penetrations: All enclosure penetrations shall be from the bottom of the enclosure unless the system design requires penetrations from other directions. Penetrations of interior enclosures involving

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

transitions of conduit from interior to exterior, and all penetrations on exterior enclosures shall be sealed with rubber silicone sealant to preclude the entry of water and will comply with VA Master Specification 07 84 00, Firestopping. The conduit riser shall terminate in a hot-dipped galvanized metal cable terminator. The terminator shall be filled with an approved sealant as recommended by the cable manufacturer and in such a manner that the cable is not damaged.

L. Cold Galvanizing: All field welds and brazing on factory galvanized boxes, enclosures, and conduits shall be coated with a cold galvanized paint containing at least 95 percent zinc by weight.

M. Control Panels:

1. Connect power and signal lines to the controller.
2. Program the panel as outlined by the design and per the manufacturer's programming guidelines.

N. SMS:

1. Coordinate with the VA agency's IT personnel to place the computer on the local LAN or Intranet and provide the security system protection levels required to insure only authorized VA personnel have access to the system.
2. Program and set-up the SMS to ensure it is in fully operation.

O. Card Readers:

1. Connect all signal inputs and outputs as shown and specified.
2. Terminate input signals as required.
3. Program and address the reader as per the design package.
4. Readers shall be surface or flushed mounted and all appropriate hardware shall be provided to ensure the unit is installed in an enclosed conduit system.

P. Biometrics:

1. Connect all signal input and output cables along with all power cables.
2. Program and ensure the device is in operating order.

Q. Portal Control Devices:

1. Install all signal input and output cables as well as all power cables.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

2. Devices shall be surface or flush mounted as per the design package.
3. Program all devices and ensure they are working.

R. Door Status Indicators:

1. Install all signal input and output cables as well as all power cables.
2. RTE's shall be surface mounted and angled in a manner that they cannot be compromised from the non-secure side of a windowed door or allow for easy release of the locking device from a distance no greater than 6 feet from the base of the door.
3. Door position sensors shall be surface or flush mounted and wide gap with the ability to operate at a maximum distance of up to 2" (5 cm) .

S. Entry Control Devices:

1. Install all signal input and power cables.
2. Strikes and bolts shall be mounted within the door frame.
3. Mortise locks shall be mounted within the door and an electric transfer hinge shall be utilized to transfer the wire from within the door frame to the mortise lock inside the door.
4. Electromagnetic locks shall be installed with the maglock mounted to the door frame and the metal plate mounted to the door.

T. System Start-Up:

1. The Contractor shall not apply power to the PACS until the following items have been completed:
 - a. PACS equipment items and have been set up in accordance with manufacturer's instructions.
 - b. A visual inspection of the PACS has been conducted to ensure that defective equipment items have not been installed and that there are no loose connections.
 - c. System wiring has been tested and verified as correctly connected as indicated.
 - d. All system grounding and transient protection systems have been verified as installed and connected as indicated.
 - e. Power supplies to be connected to the PACS have been verified as the correct voltage, phasing, and frequency as indicated.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 13 00 - 63
Physical Access Control System

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

2. Satisfaction of the above requirements shall not relieve the Contractor of responsibility for incorrect installation, defective equipment items, or collateral damage as a result of Contractor work efforts.
3. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the Resident Engineer and Commissioning Agent. Provide a minimum of 7 days prior notice.

U. Supplemental Contractor Quality Control:

1. The Contractor shall provide the services of technical representatives who are familiar with all components and installation procedures of the installed PACS; and are approved by the Contracting Officer.
2. The Contractor will be present on the job site during the preparatory and initial phases of quality control to provide technical assistance.
3. The Contractor shall also be available on an as needed basis to provide assistance with follow-up phases of quality control.
4. The Contractor shall participate in the testing and validation of the system and shall provide certification that the system installed is fully operational as all construction document requirements have been fulfilled.

3.9 SYSTEM SOFTWARE (NOT USED)

3.10 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections [, and to assist in field testing]. Report results in writing.
- B. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports:
- C. Perform the following field tests and inspections and prepare test reports:
 1. LAN Cable Procedures: Inspect for physical damage and test each conductor signal path for continuity and shorts. Use Class 2,

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 13 00 - 64
Physical Access Control System

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

- bidirectional, Category 6A tester. Test for faulty connectors, splices, and terminations. Test according to TIA/EIA-568-1, "Commercial Building Telecommunications Cabling Standards - Part 1 General Requirements." Link performance for UTP cables must comply with minimum criteria in TIA/EIA-568-B.
2. Test each circuit and component of each system. Tests shall include, but are not limited to, measurements of power supply output under maximum load, signal loop resistance, and leakage to ground where applicable. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of the calculated battery operating time. Provide special equipment and software if testing requires special or dedicated equipment.
 3. Operational Test: After installation of cables and connectors, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.

3.11 PROTECTION

- A. Maintain strict security during the installation of equipment and software. Rooms housing the control station, and workstations that have been powered up shall be locked and secured, with an activated burglar alarm and access-control system reporting to a Central Station complying with UL 1610, "Central-Station Burglar-Alarm Units," during periods when a qualified operator in the employ of Contractor is not present.

3.12 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 28 08 00 - COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 28 08 00 -

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY SYSTEMS and related
sections for contractor responsibilities for system commissioning.

3.13 DEMONSTRATION AND TRAINING (NOT USED)

-----END-----

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 13 00 - 66
Physical Access Control System

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

SECTION 28 23 00
VIDEO SURVEILLANCE

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide and install a Video Surveillance System and associated components as indicated on the contract documents, which is identified as the Video Assessment and Surveillance System hereinafter referred to as the VASS System as specified in this section.
- B. This section includes video surveillance system consisting of cameras, data transmission wiring, and a control/ recording station with its associated equipment.
- C. Cameras and Recording devices are to be NDAA compliant.
- D. Provide all labor, hardware, programming, licensing, testing, and commissioning as required for a complete operational solution and as specified herein.

1.2 RELATED WORK

- A. Section 01 00 00 - GENERAL REQUIREMENTS. For General Requirements.
- B. Section 07 84 00 - FIRESTOPPING. Requirements for firestopping application and use.
- C. Section 10 14 00 - SIGNAGE. Requirements for labeling and signs.
- D. Section 26 05 11 - REQUIREMENTS FOR ELECTRICAL INSTALLATIONS. Requirements for connection of high voltage.
- E. Section 26 05 21 - LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW). Requirements for power cables.
- F. Section 28 05 00 - COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY. Requirements for general requirements that are common to more than one section in Division 28.
- G. Section 28 05 13 - CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY. Requirements for conductors and cables.
- H. Section 28 05 26 - GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY. Requirements for grounding of equipment.
- I. Section 28 05 28.33 - CONDUITS AND BACKBOXES FOR ELECTRONIC SAFETY AND SECURITY. Requirements for infrastructure.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 23 00 - 1
Video Surveillance

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

J. Section 28 08 00 - COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY.

Requirements for commissioning, systems readiness checklists, and training.

K. Section 28 13 00 - PHYSICAL ACCESS CONTROL SYSTEM. Requirements for physical access control system integration.

1.3 DEFINITIONS

A. AGC: Automatic gain control.

B. B/W: Black and white.

C. CCD: Charge-coupled device.

D. CIF: Common Intermediate Format CIF images are 352 pixels wide and 88/240 (PAL/NTSC) pixels tall (352 x 288/240).

E. 4CIF: resolution is 704 pixels wide and 576/480 (PAL/NTSC) pixels tall (704 x 576/480).

F. H.264 (also known as MPEG4 Part 10): an encoding format that compresses video more effectively than older (MPEG4) standards.

G. IPS: Images per second.

H. MPEG: Moving picture experts group.

I. MPEG4: a video encoding and compression standard that uses inter-frame encoding to significantly reduce the size of the video stream being transmitted.

J. NTSC: National Television System Committee.

K. UPS: Uninterruptible power supply.

L. PTZ: refers to a movable camera that has the ability to pan left and right, tilt up and down, and zoom or magnify a scene.

1.4 QUALITY ASSURANCE

A. The Contractor shall be responsible for providing, installing, and the operation of the VASS System as shown. The Contractor shall also provide certification as required.

B. The security system shall be installed and tested to ensure all components are fully compatible as a system and can be integrated with all associated security subsystems, whether the security system is stand-alone or a part of a complete Information Technology (IT) computer network.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 23 00 - 2
Video Surveillance

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

- C. The Contractor or security sub-contractor shall be a licensed security Contractor as required within the state or jurisdiction of where the installation work is being conducted.
- D. Manufacturers Qualifications: The manufacturer shall regularly and presently produce, as one of the manufacturer's principal products, the equipment and material specified for this project, and shall have manufactured the item for at least three years.
- E. Product Qualification:
1. Manufacturer's product shall have been in satisfactory operation, on three installations of similar size and type as this project, for approximately three years.
 2. The Government reserves the right to require the Contractor to submit a list of installations where the products have been in operation before approval.
- F. Contractor Qualification:
1. The Contractor or security sub-contractor shall be a licensed security Contractor with a minimum of five (5) years experience installing and servicing systems of similar scope and complexity. The Contractor shall be an authorized regional representative of the Video Assessment and Surveillance System's (VASS) manufacturer. The Contractor shall provide four (4) current references from clients with systems of similar scope and complexity which became operational in the past three (3) years. At least three (3) of the references shall be utilizing the same system components, in a similar configuration as the proposed system. The references must include a current point of contact, company or agency name, address, telephone number, complete system description, date of completion, and approximate cost of the project. The owner reserves the option to visit the reference sites, with the site owner's permission and representative, to verify the quality of installation and the references' level of satisfaction with the system. The Contractor shall provide copies of system manufacturer certification for all technicians. The Contractor shall only utilize factory-trained technicians to install, program, and service the VASS. The

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 23 00 - 3
Video Surveillance

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

- Contractor shall only utilize factory-trained technicians to install, terminate and service cameras, control, and recording equipment. The technicians shall have a minimum of five (5) continuous years of technical experience in electronic security systems. The Contractor shall have a local service facility. The facility shall be located within 60 miles of the project site. The local facility shall include sufficient spare parts inventory to support the service requirements associated with this contract. The facility shall also include appropriate diagnostic equipment to perform diagnostic procedures. The COTR reserves the option of surveying the company's facility to verify the service inventory and presence of a local service organization.
2. The Contractor shall provide proof project superintendent with BICSI Certified Commercial Installer Level 1, Level 2, or Technician to provide oversight of the project.
 3. Cable installer must have on staff a Registered Communication Distribution Designer (RCDD) certified by Building Industry Consulting Service International. The staff member shall provide consistent oversight of the project cabling throughout design, layout, installation, termination, and testing.
- G. Service Qualifications: There shall be a permanent service organization maintained or trained by the manufacturer which will render satisfactory service to this installation within four hours of receipt of notification that service is needed. Submit name and address of service organizations.

1.5 SUBMITTALS

- A. Refer to 25 05 00 COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY, Part 1

1.6 APPLICABLE PUBLICATIONS

- A. Refer to 25 05 00 COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY, Part 1

1.7 COORDINATION

- A. Coordinate arrangement, mounting, and support of video surveillance equipment:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 23 00 - 4
Video Surveillance

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 3. To allow right of way for piping and conduit installed at required slope.
 4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- C. Coordinate location of access panels and doors for video surveillance items that are behind finished surfaces or otherwise concealed.

1.8 WARRANTY OF CONSTRUCTION

- A. Warrant VASS System work subject to the Article "Warranty of Construction" of FAR clause 52.246-21.
- B. Demonstration and training shall be performed prior to system acceptance.

PART 2 - PRODUCTS

2.1 CAMERAS

- A. Cameras shall match type and model currently in place.

2.2 DIGITAL BASED VIDEO MANAGEMENT SYSTEM

- A. Shall be an extension to the existing video management solution currently in place.

2.3 VIDEO CAMERAS

- A. The cameras shall be high-resolution color video cameras with wide dynamic range capturing capability.
- B. Megapixel High Definition Integrated Digital Network Camera
1. The network camera shall offer dual video streams with up to 5-megapixel resolution (2592 x 1944) in progressive scan format.
 2. An alarm input and relay output shall be built in for integration with hard wired external sensors.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 23 00 - 5
Video Surveillance

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

3. The network camera shall be capable of firmware upgrades through a network using a software-based device utility.
4. The network camera shall offer auto back focus (ABF) functionality through a push button on the camera. ABF parameters shall also be configurable through a standard Web browser interface.
5. The network camera shall offer a video output port providing an NTSC/PAL analog video output signal for adjusting field of view and focus at the camera.
6. The network camera shall provide advanced low-light capabilities for color and day/night models with sensitivity down to 0.12 lux in color and 0.03 lux in black-white (B-W).
7. The network camera shall have removable IR cut filter mechanism for increased sensitivity in low-light installations. The sensitivity of IR cut filter removal shall be configurable through a Web browser.
8. The network camera shall support two simultaneous, configurable video streams. H.264 and MJPEG compression formats shall be available for primary and secondary streams with selectable unicast and multicast protocols. The streams shall be configurable in a variety of frame rates and bit rates.
9. The network camera shall support industry standard Power over Ethernet (PoE)
10. IEEE 802.3af to supply power to the camera over the network. The network camera shall also offer a 24 VAC power input for optional use.
11. The network camera shall use a standard Web browser interface for remote administration and configuration of camera parameters.
12. The network camera shall have a window blanking feature to conceal user-defined privacy areas that cannot be viewed by an operator. The network camera shall support up to four blanked windows. A blanked area shall appear on the screen as a solid gray window.
13. The network camera shall support standard IT protocols.
14. The network camera shall support open architecture best practices with a published API available to third-party network video recording and management systems.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 23 00 - 6
Video Surveillance

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

15. Megapixel High Definition Integrated Digital Network Camera
Technical Specifications:

Imaging Device	1/1.8" 6MP CMOS
Imager Type	CMOS, Progressive scan
Maximum Resolution	2592 x 1944
Signal-to-Noise Ratio	50 dB
Auto Iris Lens Type	DC drive
Electronic Shutter Range	1~1/100,000 sec
Wide Dynamic Range	60 dB
White Balance Range	2,000° to 10,000°K
Sensitivity	f/1.2; 2,850K; SNR >24dB Color (1x/33ms) 0.50 lux Color SENS (15x/500 ms) 0.12 lux Mono SENS (15x/500 ms) Mono (1x/33ms) 0.25 lux 0.03 lux
Dome Attenuation	Clear Zero light loss Smoke f/1.0 light loss
Compression	H2.65, H.264 in base profile and MJPEG
Video Streams	Up to 2 simultaneous streams, the second Stream variable based on the setup of the primary stream
Frame Rate	Up to 30, 25, 24, 15, 12.5, 12, 10, 8, 7.5, 6.5, 4, 3, 2, and 1 (depending upon coding, resolution, and stream configuration
Available Resolutions	2560x1920, 2560x1440, 1920x1080, 1600x1200, 1280x1024, 1280x960, 1280x720, 1024x768, 800x600, 800x448, 720x576, 720x480, 640x480, 640x360, 320x240
Supported Protocols	TCP/IP, UDP/IP (Unicast, Multicast IGMP), UPnP, DNS, DHCP, RTP, RTSP, NTP, IPv4, SNMP, QoS, HTTP, HTTPS, LDAP(client), SSH, SSL, STMP, FTP, MDNS(Bonjour), and 802.1x (EAP)
Security Access	Password protected

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 23 00 - 7
Video Surveillance

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

Software Interface	Web browser view and setup, up to 16 cameras
Connectors	RJ-45 for 100Base-TX, Auto MDI/MDI-X
Cable	Cat5 cable or better for 100Base-TX
Input Voltage	24 VAC or PoE (IEEE802.3af class 3)
Power Consumption	PoE: Max 12.95W, typical 10.10W 12VDC: Max 11.7W, typical 7.90W
Alarm Input	10 VDC maximum, 5 mA maximum
Alarm Output	0 to 15 VDC maximum, 75 mA maximum
Lens	Motorized varifocal, DC auto iris, P iris
Pan/Tilt Adjustment	Pan 368° Tilt 160° (10° to 170°) Rotate 355°

16. Accessories

- a. Pendant mount
- b. Wall mount for pendant

17. Recommended Lenses

- a. Megapixel lens, varifocal, 3.9~9.4 mm, f/1.3

C. CAMERA HOUSINGS AND MOUNTS

1. This section pertains to all interior and exterior housings, domes, and applicable wall, ceiling, corner, pole, and rooftop mounts associated with the housing. Housings and mounts shall be specified in accordance with the type of cameras used.
2. All cameras and lenses shall be enclosed in a tamper resistant housing. Any additional mounting hardware required to install the camera housing at its specified location shall be provided along with the housing.
3. The camera and lens contained inside the housing shall be installed on a camera mount. All additional mounting hardware required to

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 23 00 - 8
Video Surveillance

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

- install the camera housing at its specified location shall be provided along with the housing.
4. Shall be manufactured in a manner that are capable of supporting a maximum of three (3) cameras with housings and meet environmental requirements for the geographical area the camera support equipment is being installed on or within.
 5. Environmentally Sealed
 - a. Shall be designed in manner that it provides a condensation free environment for correct camera operation.
 - b. Shall be operated in a 100 percent condensing humidity atmosphere.
 - c. Shall be constructed in a manner that:
 - 1) Has a fill valve to allow for the introduction of nitrogen into the housing to eliminate existing atmospheric air and pressurize the housing to create moisture free conditions.
 - 2) Has an overpressure valve to prevent damage to the housing in the event of over pressurization.
 - 3) Is equipped with a humidity indicator that is visible to the eye to ensure correct atmospheric conditions at all times.
 - 4) The leak rate of the housing is not to be greater than 13.8kPa or 2 pounds per square inch at sea level within a 90-day period.
 - 5) It shall contain camera mounts or supports as needed to allow for correct positioning of the camera and lens.
 - 6) The housing and sunshield are to be white in color.
 6. All electrical and signal cables required for correct operations shall be supplied in a hardened carrier system from the controller to the camera.
 7. The mounting bracket shall be adjustable to allow for the housing weight of the camera and the housing unit it is placed in.
 8. Accessibility to the camera and mounts shall be taken into consideration for maintenance and service purposes.

D. Indoor Mounts

1. Wall Mounts:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 23 00 - 9
Video Surveillance

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

- a. The enclosure shall be installed in manner that it matches the existing décor and placed at a height that it will be unobtrusive, unable to cause personal harm, and prevents tampering and vandalism.
 - b. The mount shall contain a manual pan/tilt head that will provide 360 degrees of horizontal and vertical positioning from a horizontal position and has a locking bar or screw to maintain its fixed position once it has been adjusted.
- E. Interior Domes
1. The interior dome shall be a pendant mount, pole mount, ceiling mount, surface mount, or corner mounted equipment.
 2. The lower portion of the dome that provides camera viewing shall be made of black opaque acrylic and shall have a light attenuation factor of no more than 1 f-stop.
 3. The housing shall be equipped with integral pan/tilt capabilities complete with wiring, wiring harness, connectors, receiver/driver, pan/tilt control system, pre-position cards, or any other hardware and equipment as needed to fully provide a fully functional pan/tilt dome.

2.4 RECORDING DEVICES

- A. All cameras on the VASS System shall be recorded in real time using a Network Video Recorder (NVR) or attached storage. The type of recording device utilized should be determined by the size and type of VASS System designed and installed, and to what extent the system is to be utilized.
- B. All recording devices shall be 47.5 cm (19 inch) rack mountable.
- C. All NVR's that are viewable over an Intranet or Internet will be routed through an encryptor.
- D. Encryptors shall:
 1. Comply with FIPS PUB 140-2.
 2. Support TCP/IP.
 3. Directly interfaces to low-cost commercial routers.
 4. Provide packet-based crypto synchronization.
 5. Encrypt source and destination IP addresses.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 23 00 - 10
Video Surveillance

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

6. Support web browser-based management requiring no additional software.
 7. Have a high data sustained throughput – 1.544 Mbps (T1) full duplex data rate.
 8. Provide for both bridging and routing network architecture support.
 9. Support Electronic Key Management System (EKMS) compatible.
 10. Have remote management ability.
 11. Automatically reconfigure when secure network or wide area network changes.
- E. Network Video Recorder (NVR)
1. Shall record video to a hard drive-based digital storage medium in MPEG, MPEG4 or H.264 format.
 2. Shall meet the following minimum requirements:
 - a. Record at minimum rate of 30 IPS.
 - b. Have a minimum of eight (8) to 16 looping inputs.
 - c. Have a minimum of eight (8) to 16 alarm inputs and two (2) relay outputs.
 - d. Shall provide instantaneous playback of all recorded images.
 - e. Be IP addressable, if part of a VASS network.
 - f. Have built-in digital motion detection with masking and sensitivity adjustments.
 - g. Easy playback and forward/reverse search capabilities.
 - h. Complete audit trail database, with minimum of a six-month history that tracks all events related to the alarm; specifically, who, what, where and when.
 - i. NVR management capability providing automatic video routing to a back-up spare recorder in case of failure.
 - j. Accessible locally and remotely via the internet, intranet, or a personal digital assistant (PDA).
 - k. Records all alarm events in real time, ensuring 60 seconds before and after the event are included in the recording.
 - l. Utilize RS-232 or fiber optic connections for integration with the SMS computer station via a remote port on a network hub.
 - m. Allow for independently adjustable frame rate settings.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 23 00 - 11
Video Surveillance

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

n. Be compatible with the matrix switcher utilized to operate the cameras.

3. Recording Parameters

a. Recording shall be calculated to provide 30 days of storage based on:

- 1) 15 FPS
- 2) 20% Motion
- 3) Full resolution
- 4) H.264 Codec

b. Provide 20% spare capacity with licenses and recording capacity.

4. Technical Characteristics:

Hardware/CPU	Pentium III Xeon or IV, 1.8 GHz
HDD Interface	IDE or better; optional: SCSI II, SCSI Ultra, or Fiber Channel
RAM	1024 MB
Operating System	Windows 2000/XP Professional/Server 2003 Standard
Graphic	Card VGA
Ethernet Card	100/1000 MB
Memory	20 MB
Software Setup	Centralized setup from each authorized PC; access via integrated web server
Storage Media	All storage media possible (e.g., HD, RAID), depending on operating system
Storage Mode	Linear mode, ring mode (capacity-based)
Recording Configuration	Camera name assignment, bandwidth limit, frame rate, video quality
Recording Content	Video and/or audio data
Search Parameters	Time, date, event
Playback	Playback via any IP network (LAN/WAN) simultaneous recording, playback, and backup
Network Interface	Ethernet (RJ-45, 10/100M)
Network Protocol	TCP/IP, DHCP, HTTP, UDP
Network Capabilities	Live/Playback/P/T/Z control

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 23 00 - 12
Video Surveillance

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

Recording Rate	30 ips for 720 x 240 (NTSC)
Password Protection	Menu Setup, Remote Access
Recording Capacity	160 (1 or 2 fixed HDD) 1 CD-RW
Power Interrupt	Auto recovered to recording mode

2.5 WIRES AND CABLES

- A. Shall meet or exceed the manufactures recommendation for power and signal.
- B. Will be carried in an enclosed conduit system, utilizing electromagnetic tubing (EMT) to include the equivalent in flexible metal, rigid galvanized steel (RGS) to include the equivalent of liquid tight, polyvinylchloride (PVC) schedule 40 or 80.
- C. All conduits will be sized and installed per the NEC. All security system signal and power cables that traverse or originate in a high security office space will contained in either EMT or RGS conduit.
- D. All conduit, pull boxes, and junction boxes shall be clearly marked with colored permanent tape or paint that will allow it to be distinguished from all other conduit and infrastructure.
- E. Conduit fills shall not exceed 50 percent unless otherwise documented.
- F. A pull string shall be pulled along and provided with signal and power cables to assist in future installations.
- G. At all locations where there is a wall penetration or core drilling is conducted to allow for conduit to be installed, fire stopping materials shall be applied to that area
- H. High voltage and signal cables shall not share the same conduit and shall be kept separate up to the point of connection. High voltage for the security system shall be defined as any cable or sets of cables carrying 30 VDC/VAC or higher.
- I. For all equipment that is carrying digital data between the Physical Access Control System and Database Management or at a remote monitoring station, shall not be less that 20 AWG and stranded copper wire for each conductor. The cable or each individual conductor within the cable

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

shall have a shield that provides 100% coverage. Cables with a single overall shield shall have a tinned copper shield drain wire.

- J. All cables and conductors, except fiber optic cables, that act as a control, communication, or signal lines shall include surge protection. Surge protection shall be furnished at the equipment end and additional triple electrode gas surge protectors rated for the application on each wire line circuit shall be installed within 1 m. (3 ft.) of the building cable entrance. The inputs and outputs shall be tested in both normal and common mode using the following wave forms:

K. Signal Cables:

- a. Signal wiring for PoE cameras depends on the distance the camera is being installed from either a hub or the server.
- b. If the camera is up to 300 ft from a hub or the server, then use a UTP category 6A (CAT-V) cable with standard RJ-45 connector at each end. The cable shall comply with the Power over Ethernet, IEEE802.3af, Standard.

PART 3 - EXECUTION

3.1. GENERAL

- A. Installation: The Contractor shall install all system components including Owner furnished equipment, and appurtenances in accordance with the manufacturer's instructions, ANSI C2 and as shown, and shall furnish all necessary connectors, terminators, interconnections, services, and adjustments required for a complete and operable data transmission system.
- B. Identification and Labeling: The Contractor shall supply permanent identification labels for each cable at each end that will appear on the as-built drawings. The labeling format shall be identified, and a complete record shall be provided to the Owner with the final documentation. Each cable shall be identified by type or signal being carried and termination points. The labels shall be printed on letter size label sheets that are self-laminated vinyl that can be printed from a computer data base or spread sheet. The labels shall be E-Z code WES12112 or equivalent.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 23 00 - 14
Video Surveillance

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

1. The Contractor shall provide all personnel, equipment, instrumentation, and supplies necessary to perform all testing.
- C. Transient Voltage Surge Suppressors (TVSS): The Contractor shall mount TVSS within 3 m (118 in) of equipment to be protected inside terminal cabinets or suitable NEMA 1 enclosure. Terminate off-premises conductors on input side of device. Connect the output side of the device to the equipment to be protected. Connect ground lug to a low impedance earth ground (less than 10 ohms) via Number 12 AWG insulated, stranded copper conductor.
- D. Contractor's Field Test: The Contractor shall verify the complete operation of the data transmission system during the Contractor's Field Testing. Field test shall include a bit error rate test. The Contractor shall perform the test by sending a minimum of 1,000,000 bits of data on each DTM circuit and measuring the bit error rate. The bit error rate shall not be greater than one (1) bit out of each 100,000 bits sent for each dial-up DTM circuit, and one (1) bit out of 1,000,000 bits sent for each leased or private DTM circuit. The Contractor shall submit a report containing results of the field test.
- E. Acceptance Test and Endurance Test: The wire line data transmission system shall be tested as a part of the completed IDS and EECS during the Acceptance test and Endurance Test as specified.
- F. Identification and Labeling: The Contractor shall supply identification tags or labels for each cable. Cable shall be labeled at both end points and at intermediate hand holes, manholes, and junction boxes. The labeling format shall be identified, and a complete record shall be provided to the Owner with the final documentation. Each cable shall be identified with type of signal being carried and termination points.

3.2 INSTALLATION

- A. System installation shall be in accordance with NECA 303, manufacturer and related documents and references, for each type of security subsystem designed, engineered and installed.
- B. Components shall be configured with appropriate "service points" to pinpoint system trouble in less than 30 minutes.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 23 00 - 15
Video Surveillance

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

- C. The Contractor shall install all system components including Government furnished equipment, and appurtenances in accordance with the manufacturer's instructions, documentation listed in Sections 1.5 of this document, and shall furnish all necessary connectors, terminators, interconnections, services, and adjustments required for a complete and operable system.
- D. The VASS System will be designed, engineered, installed, and tested to ensure all components are fully compatible as a system and can be integrated with all associated security subsystems, whether the system is a standalone or a complete network.
- E. For integration purposes, the VASS System shall be integrated where appropriate with the following associated security subsystems:
 - 1. PACS:
 - a. Provide 24-hour coverage of all entry points to the perimeter and agency buildings, as well as all emergency exits utilizing a fixed color camera.
 - b. Record cameras on a 24 hours basis.
 - c. Be programmed go into an alarm state when an emergency exit is opened and notify the Physical Access Control System and Database Management of an alarm event.
 - 2. IDS:
 - a. Provide a recorded alarm event via a color camera that is connected to the IDS system by either direct hardwire or a security system computer network.
 - b. Record cameras on a 24 hours basis.
 - c. Be programmed to go into an alarm state when an IDS device is put into an alarm state and notify the PACS.
 - d. For additional VASS System requirements as they relate to the IDS, refer to Section 28 16 00 "INTRUSION DETECTION".
 - 3. Security Access Detection:
 - a. Provide full coverage of all vehicle and lobby entrance screening areas utilizing a fixed color camera.
 - b. Record cameras on a 24 hours basis.
 - 4. EPPS:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 23 00 - 16
Video Surveillance

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

- a. Provide a recorded alarm event via a color camera that is connected to the EPPS system by either direct hardwire or a security system computer network.
 - b. Record cameras on a 24 hours basis.
 - c. Be programmed to go into an alarm state when an emergency call box or duress alarm/panic device is activated and notify the Physical Access Control System and Database Management of an alarm event.
- F. Integration with these security subsystems shall be achieved by computer programming or the direct hardwiring of the systems.
- G. For programming purposes refer to the manufacturers requirements for correct system operations. Ensure computers being utilized for system integration meet or exceed the minimum system requirements outlined on the systems software packages.
- H. A complete VASS System shall be comprised of, but not limited to, the following components:
- 1. Cameras
 - 2. Lenses
 - 3. Video Display Equipment
 - 4. Camera Housings and Mounts
 - 5. Controlling Equipment
 - 6. Recording Devices
 - 7. Wiring and Cables
- I. The Contractor shall visit the site and verify that site conditions are in agreement/compliance with the design package. The Contractor shall report all changes to the site or conditions that will affect performance of the system to the Contracting Officer in the form of a report. The Contractor shall not take any corrective action without written permission received from the Contracting Officer.
- J. Existing Equipment
- 1. The Contractor shall connect to and utilize existing video equipment, video and control signal transmission lines, and devices as outlined in the design package. Video equipment and signal lines

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 23 00 - 17
Video Surveillance

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

- that are usable in their original configuration without modification may be reused with Contracting Officer approval.
2. The Contractor shall perform a field survey, including testing and inspection of all existing video equipment and signal lines intended to be incorporated into the VASS System, and furnish a report to the Contracting Officer as part of the site survey report. For those items considered nonfunctioning, provide (with the report) specification sheets, or written functional requirements to support the findings and the estimated cost to correct the deficiency. As part of the report, the Contractor shall include a schedule for connection to all existing equipment.
 3. The Contractor shall make written requests and obtain approval prior to disconnecting any signal lines and equipment and creating equipment downtime. Such work shall proceed only after receiving Contracting Officer approval of these requests. If any device fails after the Contractor has commenced work on that device, signal or control line, the Contractor shall diagnose the failure and perform any necessary corrections to the equipment.
 4. The Contractor shall be held responsible for repair costs due to Contractor negligence, abuse, or incorrect installation of equipment.
 5. The Contracting Officer shall be provided a full list of all equipment that is to be removed or replaced by the Contractor, to include description and serial/manufacturer numbers where possible. The Contractor shall dispose of all equipment that has been removed or replaced based upon approval of the Contracting Officer after reviewing the equipment removal list. In all areas where equipment is removed or replaced the Contractor shall repair those areas to match the current existing conditions.
- K. Enclosure Penetrations: All enclosure penetrations shall be from the bottom of the enclosure unless the system design requires penetrations from other directions. Penetrations of interior enclosures involving transitions of conduit from interior to exterior, and all penetrations on exterior enclosures shall be sealed with rubber silicone sealant to

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 23 00 - 18
Video Surveillance

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

preclude the entry of water and will comply with VA Master Specification 07 84 00, Firestopping. The conduit riser shall terminate in a hot-dipped galvanized metal cable terminator. The terminator shall be filled with an approved sealant as recommended by the cable manufacturer and in such a manner that the cable is not damaged.

L. Cameras:

1. Install the cameras with the focal length lens as indicated for each zone.
2. Connect power and signal lines to the camera.
3. Aim camera to give field of view as needed to cover the alarm zone.
4. Aim fixed mounted cameras installed outdoors facing the rising or setting sun sufficiently below the horizon to preclude the camera looking directly at the sun.
5. Focus the lens to give a sharp picture (to include checking for day and night focus and image quality) over the entire field of view
6. Synchronize all cameras so the picture does not roll on the monitor when cameras are selected.
7. PTZ cameras shall have all preset positions and privacy areas defined and programmed.

M. Network Recording Equipment

1. Install the NVR or video storage unit as shown in the design and construction documents, and as specified by the OEM.
2. Connect recording device to AC power (UPS).
3. Connect recording device to network switch as shown and specified.
4. Configure network connections
5. Provide recording unit programming per VA guidance and the requirements provided by the Owner. Programming shall include:
 - a. Camera names
 - b. Screen views
 - c. Camera recording schedules (continuous and event) driven recording. Events include alarms from other systems (sensors), manual input, and video motion detection.
 - d. Video detection zones for each camera requiring video motion detection

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 23 00 - 19
Video Surveillance

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

- e. Alarm interface
 - f. Alarm outputs
 - g. GUI maps, views, icons and actions
 - h. PTZ controls (presets, time schedules for privacy zones etc.)
- N. Video Signal Equipment:
- 1. Install the video signal equipment as shown in the design and construction documents, and as specified by the OEM.
 - 2. Connect video or signal inputs and outputs as shown and specified.
 - 3. Terminate video inputs as required.
 - 4. Connect alarm signal inputs and outputs as required.
 - 5. Connect control signal inputs and outputs as required
 - 6. Connect electrically powered equipment to AC power.
- O. Camera Housings, Mounts, and Poles:
- 1. Install the camera housings and mounts as specified by the manufacturer and as shown, provide mounting hardware sized appropriately to secure each camera, housing and mount with maximum wind and ice loading encountered at the site.

3.3 SYSTEM START-UP

- A. The Contractor shall not apply power to the VASS System until the following items have been completed:
- 1. VASS System equipment items and have been set up in accordance with manufacturer's instructions.
 - 2. A visual inspection of the VASS System has been conducted to ensure that defective equipment items have not been installed and that there are no loose connections.
 - 3. System wiring has been tested and verified as correctly connected as indicated.
 - 4. All system grounding and transient protection systems have been verified as installed and connected as indicated.
 - 5. Power supplies to be connected to the VASS System have been verified as the correct voltage, phasing, and frequency as indicated.
- B. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 23 00 - 20
Video Surveillance

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

09-01-11

schedules with the Resident Engineer and Commissioning Agent. Provide a minimum of 7 days prior notice.

- C. Satisfaction of the above requirements shall not relieve the Contractor of responsibility for incorrect installation, defective equipment items, or collateral damage as a result of Contractor work efforts.

3.4 SUPPLEMENTAL CONTRACTOR QUALITY CONTROL

- A. The Contractor shall provide the services of technical representatives who are familiar with all components and installation procedures of the installed VASS System; and are approved by the Contracting Officer.
- B. The Contractor will be present on the job site during the preparatory and initial phases of quality control to provide technical assistance.
- C. The Contractor shall also be available on an as needed basis to provide assistance with follow-up phases of quality control.
- D. The Contractor shall participate in the testing and validation of the system and shall provide certification that the system installed is fully operational as all construction document requirements have been fulfilled.

3.5 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 28 08 00 - COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 28 08 00 - "COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY SYSTEMS" and related sections for contractor responsibilities for system commissioning.

3.6 DEMONSTRATION AND TRAINING

- A. All testing and training shall be compliant with the VA General Requirements, Section 01 00 00, "GENERAL REQUIREMENTS".

-----END-----

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

28 23 00 - 21
Video Surveillance

01/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

SECTION 28 31 00
FIRE DETECTION AND ALARM

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section of the specifications includes the furnishing, installation, and connection of new addressable smoke detectors to the existing building(s) fire alarm equipment in conjunction with architectural and electrical/mechanical modifications to existing room spaces for the purpose of building out new Telecommunication Rooms (TRs). It shall include, but not be limited to installing and completing programming for new addressable spot smoke detectors and modifying existing conduit and wiring as indicated on the drawings and as specified IN Part 3.1.B of this Section.
- B. Fire alarm system modifications shall comply with requirements of the most recent VA FIRE PROTECTION DESIGN MANUAL and NFPA 72 unless variations to NFPA 72 are specifically identified within these contract documents by the following notation: "variation". The design, system layout, document submittal preparation, and supervision of installation and testing shall be provided by a technician that is certified NICET level III or a registered fire protection engineer. The NICET certified technician shall be on site for the supervision and testing of the system. Installers shall have a minimum experience of 2 years installing fire alarm systems.

1.2 SCOPE

- A. Modifications to existing addressable fire alarm systems shall be designed and installed in accordance with the specifications and drawings. The installed locations of new devices shall be in accordance with NFPA 72 and this specification.
- B. Basic Performance:
 - 1. Modified signaling line circuits (SLC) within buildings shall maintain the existing circuit class as currently installed.
 - 2. Programming for new smoke detectors provided and installed shall be in accordance with the existing building fire alarm system sequence of operations based on the fire alarm notification zone each new device is located in. The annunciator text message for each new

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

smoke detector device shall include information in accordance with Part 3.2 of this Section and the existing facility text message labeling convention.

1.3 RELATED WORK

- A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. Requirements for procedures for submittals.
- B. Section 07 84 00 - FIRESTOPPING. Requirements for fire proofing wall penetrations.
- C. Section 08 71 00 - DOOR HARDWARE. For combination Closer-Holders.
- D. Section 21 13 13 - WET-PIPE SPRINKLER SYSTEMS. Requirements for sprinkler systems.
- E. Section 28 05 00 - COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY. Requirements for general requirements that are common to more than one section in Division 28.
- F. Section 28 05 13 - CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY. Requirements for conductors and cables.
- G. Section 28 05 26 - GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY. Requirements for grounding of equipment.
- H. Section 28 05 28.33 - CONDUITS AND BACKBOXES FOR ELECTRONIC SAFETY AND SECURITY. Requirements for infrastructure.
- I. Section 28 08 00, COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY SYSTEMS. Requirements for commissioning - systems readiness checklists, and training.
- J. Section 28 13 00, PHYSICAL ACCESS CONTROL SYSTEMS (PACS). Requirements for integration with physical access control system.

1.4 SUBMITTALS

- A. General: Submit 5 copies in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, and Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Drawings:
 - 1. The contractor shall modify the existing facility AutoCAD fire alarm as-built drawings to show all show all proposed circuit and device modifications to be performed under this scope of work.
 - 2. Two weeks prior to final inspection, the Contractor shall deliver to the COTR 3 sets of revised as-built drawings and one set of the as-

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

built drawing computer files (using AutoCAD 2007 or later). As-built drawings (floor plans) shall show all new and/or existing conduit used for the fire alarm system.

D. Certifications:

1. Together with the shop drawing submittal, submit the technician's NICET level III fire alarm certification as well as certification from the control unit manufacturer that the proposed performer of contract maintenance is an authorized representative of the major equipment manufacturer. Include in the certification the names and addresses of the proposed supervisor of installation and the proposed performer of contract maintenance. Also include the name and title of the manufacturer's representative who makes the certification.
2. Together with the shop drawing submittal, submit product data sheets from the control unit manufacturer that the components being furnished are compatible with the control unit.
3. Together with the shop drawing submittal, submit a certification from the major equipment manufacturer that the wiring and connection diagrams meet this specification, UL and NFPA 72 requirements.

1.5 WARRANTY

All work performed and all material and equipment furnished under this contract shall be free from defects and shall remain so for a period of one year from the date of acceptance of the entire installation by the Contracting Officer.

1.6 GUARANTY PERIOD SERVICES

- A. Contractor shall provide all necessary test equipment, parts and labor to perform required inspection, testing, maintenance and repair of the fire alarm system modifications performed under this scope of work.
- B. Non-included Work: Repair service shall not include the performance of any work due to improper use, accidents, or negligence for which the contractor is not responsible.

1.7 APPLICABLE PUBLICATIONS

- A. The publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. The publications are referenced in text by the

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

basic designation only and the latest editions of these publications shall be applicable.

B. National Fire Protection Association (NFPA):

NFPA 70 National Electrical Code (NEC), 2022 edition

NFPA 72 National Fire Alarm Code, 2022 edition

NFPA 101 Life Safety Code, 2022 edition

C. Underwriters Laboratories, Inc. (UL): Fire Protection Equipment Directory

D. Factory Mutual Research Corp (FM): Approval Guide

E. American National Standards Institute (ANSI):

S3.41 Audible Emergency Evacuation Signal, 1990
edition, reaffirmed 2008

F. International Code Council, International Building Code (IBC), 2021 edition

PART 2 - PRODUCTS

2.1 EQUIPMENT AND MATERIALS, GENERAL

A. All equipment and components shall be new and the manufacturer's current model. All equipment shall be tested and listed by Underwriters Laboratories, Inc. or Factory Mutual Research Corporation for use as part of a fire alarm system. The authorized representative of the manufacturer of the major equipment shall certify that the installation complies with all manufacturers' requirements and that satisfactory total system operation has been achieved.

2.2 CONDUIT, BOXES, AND WIRE

A. Conduit shall be in accordance with Section 28 05 28.33 CONDUIT AND BACKBOXES FOR ELECTRONIC SAFETY AND SECURITY and as follows:

1. All new conduits shall be installed in accordance with NFPA 70.
2. Conduit fill shall not exceed 40 percent of interior cross sectional area.
3. All new conduits shall be 3/4 inch minimum.
4. Reference Part 3.1.C of this Section for painting requirements.

B. Wire:

1. Wiring shall be in accordance with NEC article 760, Section 28 05 13, CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY, and as recommended by the manufacturer of the fire alarm system. All wires

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

shall be color coded. Number and size of conductors shall be as recommended by the fire alarm system manufacturer, but not less than 18 AWG for initiating device circuits and 14 AWG for notification device circuits.

2. Addressable circuits and wiring shall be twisted and shielded unless specifically excepted by the fire alarm equipment manufacturer in writing.
3. All fire alarm system wiring shall be solid copper, unless specifically noted otherwise.

C. Terminal Boxes, Junction Boxes, and Cabinets:

1. Shall be galvanized steel in accordance with UL requirements.
2. All boxes shall be sized and installed in accordance with NFPA 70.
3. Covers shall be painted, or repainted, red in accordance with Section 09 91 00, PAINTING and shall be identified with white markings as "FA" for junction boxes and as "FIRE ALARM SYSTEM" for cabinets and terminal boxes. Lettering shall be a minimum of 3/4 inch (19 mm) high.
4. Terminal boxes and cabinets shall have a volume 50 percent greater than required by the NFPA 70. Minimum sized wire shall be considered as 14 AWG for calculation purposes.
5. Terminal boxes and cabinets shall have identified pressure type terminal strips and shall be located at the base of each riser. Terminal strips shall be labeled as specified or as approved by the COTR.
6. Reference Part 3.1.C of this Section for painting requirements.

2.3 ALARM INITIATING DEVICES

A. Smoke Detectors:

1. Smoke detectors shall be photoelectric type and UL listed for use with the existing building fire alarm control unit.
2. Smoke detectors shall be addressable type complying with applicable UL Standards for system type detectors. Smoke detectors shall be installed in accordance with the manufacturer's recommendations and NFPA 72.
3. Detectors shall have an indication lamp to denote an alarm condition.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

4. Photoelectric detectors shall be factory calibrated and readily field adjustable. The sensitivity of any photoelectric detector shall be factory set at 3.0 plus or minus 0.25 percent obscuration per foot.
5. Detectors shall provide a visual trouble indication if they drift out of sensitivity range or fail internal diagnostics. Detectors, along with the fire alarm control units shall be UL listed for testing the sensitivity of the detectors.

2.4 SPARE AND REPLACEMENT PARTS

- A. 1. Smoke detectors - 2

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Installation shall be in accordance with NFPA 70, 72 and 101 as shown on the drawings, and as recommended by the major equipment manufacturer. Fire alarm wiring shall be installed in conduit. All conduit and wire shall be installed in accordance with, Section 28 05 13 CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY, Section 28 05 26 GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY, Section 28 05 28.33 CONDUIT AND BACKBOXES FOR ELECTRONIC SAFETY AND SECURITY, and all penetrations of smoke and fire barriers shall be protected as required by Section 07 84 00, FIRESTOPPING.
- B. All modified field circuit conductors shall land at the terminals of appliances. Field splicing of fire alarm circuits is prohibited.
- C. All conduits, junction boxes, conduit supports and hangers shall be concealed in finished areas and may be exposed in unfinished areas.
- D. All new and reused exposed conduits shall be painted in accordance with Section 09 91 00, PAINTING to match surrounding finished areas and red in unfinished areas.
- E. All existing accessible fire alarm conduit not reused shall be removed.
- F. Existing devices that are reused shall be properly mounted and installed. Where devices are installed on existing shallow backboxes, extension rings of the same material, color and texture of the new fire alarm devices shall be used. Mounting surfaces shall be cut and patched in accordance with Section 01 00 00, GENERAL REQUIREMENTS, Restoration, and be re-painted in accordance with Section 09 91 00, PAINTING as necessary to match existing.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

3.2 TYPICAL OPERATION

- A. Activation of any smoke detector shall cause the following operations to occur:
 - 1. Operate the emergency notification system and building safety functions in the building which the smoke detector is located in accordance with the current fire alarm system sequence of operations.
 - 2. Each smoke detector shall be programmed to annunciate the FLOOR LEVEL, ZONE & ROOM NAME information at the building fire alarm control unit and annunciator panels in accordance with the current fire alarm system sequence of operations.
 - 3. Alarm verification shall not be used for smoke detectors installed for the purpose of early warning.

3.3 TESTS

- A. Provide the service of a NICET level III, competent, factory-trained engineer or technician authorized by the manufacturer of the fire alarm equipment to technically supervise and participate during all of the adjustments and tests for the system. Make all adjustments and tests in the presence of the COTR.
- B. When the system modifications have been completed and prior to the scheduling of the final inspection, furnish testing equipment and perform the following tests in the presence of the COTR. When any defects are detected, make repairs or install replacement components, and repeat the tests until such time that the complete fire alarm systems meets all contract requirements. After the system has passed the initial test and been approved by the COTR, the contractor may request a final inspection.
 - 1. Before energizing the cables and wires, check for correct connections and test for short circuits, ground faults, continuity, and insulation.
 - 2. Test the insulation on all installed cable and wiring by standard methods as recommended by the equipment manufacturer.
 - 3. Open each alarm initiating circuit to see if trouble signal actuates.

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

10-01-11

4. Ground each alarm initiation and notification circuit and verify
response of trouble signals.

3.4 FINAL INSPECTION AND ACCEPTANCE

A. At the final inspection a factory trained representative of the
manufacturer of the major equipment shall repeat the tests in Article
3.3 TESTS and those required by NFPA 72. In addition the representative
shall demonstrate that the systems function properly in every respect.
The demonstration shall be made in the presence of a VA representative.

- - END - -

DIVISION 31

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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SECTION 31 11 00
CLEARING AND GRUBBING

PART 1 - GENERAL

1.01 SUMMARY

- A. Clearing vegetation, debris, trash and other materials within limits indicated.
- B. Grubbing of vegetation within limits indicated.

1.02 RELATED DOCUMENTS

- A. International Building Code: Chapter 33 – Site Work, Demolition and Construction.

PART 2 - PRODUCTS

2.01 NOT USED

PART 3 - EXECUTION

3.01 PREPARATION

- A. Locate and clearly flag vegetation to remain or to be relocated.

3.02 RESTORATION

- A. Repair or replace vegetation indicated to remain that is damaged by construction operations, as directed by the Owner.
- B. Employ a qualified arborist, licensed in jurisdiction where the Project is located, to submit details of proposed repairs and to repair damage to shrubs.

3.03 CLEARING AND GRUBBING

- A. Remove obstructions, trees, shrubs, grass, and other vegetation to permit installation of new construction. Removal includes digging out stumps and obstructions and grubbing roots.
- B. Remove trash, debris, logs, concrete, masonry and other waste materials.
- C. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
- D. Completely remove stumps, roots, obstructions, and debris extending to a depth of 18-inches below subgrade.
- E. Use only hand methods for grubbing within drip line of remaining trees. END OF SECTION

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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SECTION 31 13 00
SELECTIVE TREE REMOVAL AND TRIMMING

PART 1 - GENERAL

1.01 SUMMARY

- A. Protecting existing trees and vegetation to remain.
- B. Trimming tree limbs and roots.
- C. Removing trees as designated.

1.02 DEFINITIONS

- A. ANSI: American National Standards Institute.

1.03 QUALITY ASSURANCE

- A. Do not remove or prune trees without first securing a permit from the appropriate agency.
- B. Prune to the standards of the International Society of Arborists and to ANSI 300.

PART 2 - PRODUCTS

- A. NOT USED

PART 3 - EXECUTION

3.01 PREPARATION

- A. Locate and clearly flag trees to remain or to be relocated.

3.02 TREE PROTECTION

- A. Erect and maintain temporary fence around drip line of individual trees or around perimeter drip line of groups of trees to remain. Remove fence when construction is complete.
- B. Do not store construction materials, debris, or excavated material within drip line of remaining trees.
- C. Do not permit vehicles or equipment within drip line of remaining trees.
- D. Do not excavate within drip line of remaining trees, unless otherwise indicated.
- E. Where excavation for new construction is required within drip line of trees, hand clear and excavate to minimize damage to root systems. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation edge as possible.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- F. Cover exposed roots with burlap and water regularly.
- G. Temporarily support and protect roots from damage until they are permanently relocated and covered with soil.
- H. Coat cut faces of roots more than 1 ½ inches in diameter with an emulsified asphalt or other approved coating formulated for use on damaged plant tissues.
- I. Cover exposed roots with wet burlap to prevent roots from drying out. Backfill with soil as soon as possible.

3.03 TREE PRUNING

- A. Prune trees to balance the crown, and eliminate hazards. Perform main work to reduce sail effect through thinning, reducing end weights, shortening long heavy limbs, removing deadwood, weak limbs and sucker growth. Prune limbs back to an appropriate lateral branch.
- B. Make final cuts at the outer edge of the branch collar in accordance with the arborist's recommendations.
- C. Perform pruning work in a safe and proper manner, adhering to ANSI Standards.

3.04 ROOT PRUNING

- A. Do not cut tree roots greater than 3-inch in diameter and less than 12-inches below ground level without approval of the Owner.
- B. Cut tree roots cleanly, as far from the trunk as possible, and not underneath any area where walkways are to be constructed. Root pruning shall be to a depth of 18-inches.
- C. Tree root prune using a Vermeer root-cutting machine. Obtain the Owner's approval before using alternate equipment or techniques.
- D. Complete tree root pruning prior to any excavation adjacent to the tree.
- E. Do not expose tree roots to drying out. Cover root ends with soil or burlap and keep moist until the final backfill is completed.

3.05 TREE REMOVAL

- A. Remove trees designated for removal prior to the construction of new improvements.
- B. Perform tree removal work in a safe and proper manner, adhering to ANSI Standards.
- C. Remove or grind stumps to a minimum of 18-inches below finish subgrade. Remove surface roots to this depth within 24-inches of the tree trunk.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

3.06 RESTORATION

- A. Repair or replace trees indicated to remain that are damaged by construction operations, as directed by the Owner.
- B. Employ a qualified arborist, licensed in jurisdiction where the Project is located, to submit details of proposed repairs and to repair damage to trees.
- C. Replace trees that cannot be repaired and restored to full-growth status, as determined by the Owner.

END OF SECTION

Fargo VA Medical Center
Fargo, North Dakota 58102
EHRM Infrastructure Upgrades - Fargo ND
Bancroft Architects + Engineers

11-09-21

SECTION 31 20 00
EARTHWORK

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. This section specifies the requirements for furnishing all equipment, materials, labor, tools, and techniques for earthwork including, but not limited to, the following:

1. Site preparation.
2. Excavation.
3. Underpinning.
4. Filling and backfilling.
5. Grading.
6. Soil Disposal.
7. Clean Up.

1.2 DEFINITIONS:

A. Unsuitable Materials:

1. Fills: Topsoil; frozen materials; construction materials and materials subject to decomposition; clods of clay and stones larger than 75 mm (3 inches); organic material, including silts, which are unstable; and inorganic materials, including silts, too wet to be stable and any material with a liquid limit and plasticity index exceeding 40 and 15 respectively. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction, as defined by ASTM D698.
2. Existing Subgrade (Except Footing Subgrade): Same materials as 1.2.A.1, that are not capable of direct support of slabs, pavement, and similar items with possible exception of improvement by compaction, proofrolling, or similar methods.
3. Existing Subgrade (Footings Only): Same as paragraph 1, but no fill or backfill. If materials differ from reference borings and design

3/18/22

EHRM Infrastructure Upgrades - Fargo ND

Bancroft Architects + Engineers

11-09-21

- requirements, excavate to acceptable strata subject to Contracting Officer's Representative's approval.
- B. Building Earthwork: Earthwork operations required in area enclosed by a line located 1500 mm (5 feet) outside of principal building perimeter. It also includes earthwork required for auxiliary structures and buildings.
 - C. Trench Earthwork: Trenchwork required for utility lines.
 - D. Site Earthwork: Earthwork operations required in area outside of a line located 1500 mm (5 feet) outside of principal building perimeter and within new construction area with exceptions noted above.
 - E. Degree of compaction: Degree of compaction is expressed as a percentage of maximum density obtained by laboratory test procedure. This percentage of maximum density is obtained through use of data provided from results of field test procedures presented in ASTM D1556, ASTM D2167, and ASTM D6938.
 - F. Fill: Satisfactory soil materials used to raise existing grades. In the Construction Documents, the term "fill" means fill or backfill as appropriate.
 - G. Backfill: Soil materials or controlled low strength material used to fill an excavation.
 - H. Unauthorized excavation: Removal of materials beyond indicated sub-grade elevations or indicated lines and dimensions without written authorization by the Contracting Officer's Representative. No payment will be made for unauthorized excavation or remedial work required to correct unauthorized excavation.
 - I. Authorized additional excavation: Removal of additional material authorized by the Contracting Officer's Representative based on the determination by the Government's soils testing agency that unsuitable bearing materials are encountered at required sub-grade elevations. Removal of unsuitable material and its replacement as directed will be paid on basis of Conditions of the Contract relative to changes in work.

3/18/22

EHRM Infrastructure Upgrades - Fargo ND

Bancroft Architects + Engineers

11-09-21

- J. Subgrade: The undisturbed earth or the compacted soil layer immediately below granular sub-base, drainage fill, or topsoil materials.
- K. Structure: Buildings, foundations, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
- L. Borrow: Satisfactory soil imported from off-site for use as fill or backfill.
- M. Drainage course: Layer supporting slab-on-grade used to minimize capillary flow of pore water.
- N. Bedding course: Layer placed over the excavated sub-grade in a trench before laying pipe. Bedding course shall extend up to the springline of the pipe.
- O. Sub-base Course: Layer placed between the sub-grade and base course for asphalt paving or layer placed between the sub-grade and a concrete pavement or walk.
- P. Utilities include on-site underground pipes, conduits, ducts, and cables as well as underground services within buildings.
- Q. Debris: Debris includes all materials located within the designated work area not covered in the other definitions and shall include but not be limited to items like vehicles, equipment, appliances, building materials or remains thereof, tires, any solid or liquid chemicals or products stored or found in containers or spilled on the ground.
- R. Contaminated soils: Soil that contains contaminants as defined and determined by the Contracting Officer's Representative or the Government's testing agency.

1.3 RELATED WORK:

- A. Materials testing and inspection during construction: Section 01 45 29, TESTING LABORATORY SERVICES.
- B. Protection of existing utilities, fire protection services, existing equipment, roads, and pavements: Section 01 00 00, GENERAL REQUIREMENTS.

3/18/22

EHRM Infrastructure Upgrades - Fargo ND

Bancroft Architects + Engineers

11-09-21

- C. Subsurface Investigation: Section 01 00 00, GENERAL REQUIREMENTS, Article, PHYSICAL DATA.
- D. Erosion Control: Section 01 57 19, TEMPORARY ENVIRONMENTAL CONTROLS, and Section 32 90 00, PLANTING.
- E. Section 02 41 00, DEMOLITION.
- F. Paving sub-grade requirements: Section 32 12 16, ASPHALT PAVING.

1.4 CLASSIFICATION OF EXCAVATION:

- A. Unclassified Excavation: Removal and disposal of pavements and other man-made obstructions visible on surface; utilities, and other items including underground structures indicated to be demolished and removed; together with any type of materials regardless of character of material and obstructions encountered.
- B. Classified Excavation: Removal and disposal of all material not defined as Rock.
- C. Rock Excavation:
 - 1. Trenches and Pits: Removal and disposal of solid, homogenous, interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits that cannot be excavated with a late-model, track-mounted hydraulic excavator; equipped with a 1050 mm (42 inch) wide, short-tip-radius rock bucket; rated at not less than 103 kW (138 hp) flywheel power with bucket-curling force of not less than 125 kN (28,090 lbf) and stick-crowd force of not less than 84.5 kN (19,000 lbf); measured according to SAE J-1179. Trenches in excess of 3000 mm (10 feet) wide and pits in excess of 9000 mm (30 feet) in either length or width are classified as open excavation.
 - 2. Open Excavation: Removal and disposal of solid, homogenous, interlocking crystalline material firmly cemented, laminated, or foliated masses or conglomerate deposits that cannot be dislodged and excavated with a late-model, track-mounted loader; rated at not less than 157 kW (210 hp) flywheel power and developing a minimum of 216 kN (48,510 lbf) breakout force; measured according to SAE J-732.

3/18/22

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11-09-21

3. Other types of materials classified as rock are unstratified masses, conglomerated deposits and boulders of rock material exceeding 0.76 m³ (1 cubic yard) for open excavation, or 0.57 m³ (3/4 cubic yard) for footing and trench excavation that cannot be removed by rock excavating equipment equivalent to the above in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted.
4. Blasting: Removal and disposal of solid, homogenous, interlocking crystalline material firmly cemented, laminated, or foliated masses or conglomerate deposits that cannot be removed with conventional methods may not be performed by blasting.
5. Definitions of rock and guidelines for equipment are presented for general information purposes only. The Contractor is expected to use the information presented in the Geotechnical Engineering Report to evaluate the extent and competency of the rock and to determine both quantity estimations and removal equipment and efforts.

1.5 MEASUREMENT AND PAYMENT FOR EXCAVATION:

- A. Measurement: The unit of measurement for excavation and borrow will be the cubic yard, computed by the average end area method from cross sections taken before and after the excavation and borrow operations, including the excavation for ditches, gutters, and channel changes, when the material is acceptably utilized or disposed of as herein specified. Quantities should be computed by a Registered Professional Land Surveyor or Registered Civil Engineer, specified in Section 01 00 00, GENERAL REQUIREMENTS. The measurement will include authorized excavation for rock, authorized excavation of satisfactory subgrade soil, and the volume of loose, scattered rocks and boulders collected within the limits of the work; allowance will be made on the same basis for selected backfill ordered as replacement. The measurement will not include the volume of subgrade material or other material used for purposes other than directed. The volume of overburden stripped from borrow pits and the volume of excavation for ditches to drain borrow

3/18/22

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11-09-21

its, unless used as borrow material, will not be measured for payment. The measurement will not include the volume of any excavation performed prior to taking of elevations and measurements of the undisturbed grade.

1.6 MEASUREMENT AND PAYMENT FOR ROCK EXCAVATION:

- A. Measurement: Cross section and measure uncovered and separated materials, and compute quantities by Registered Professional Land Surveyor or Registered Civil Engineer, specified in Section 01 00 00, GENERAL REQUIREMENTS. Do not measure quantities beyond the following limits:
1. 600 mm (24 inches) from outside face of concrete work for which forms are required, except for footings.
 2. 300 mm (12 inches) from outside of perimeter of formed footings.
 3. 150 mm (6 inches) below bottom of pipe and not more than pipe diameter plus 600 mm (24 inches) in width for pipe trenches.
 4. From outside dimensions of concrete work for which no forms are required (trenches, conduits, and similar items not requiring forms).
- B. Payment: No separate payment shall be made for rock excavation quantities shown. Contract price and time will be adjusted for overruns or underruns in accordance with Articles, DIFFERING SITE CONDITIONS, CHANGES and CHANGES-SUPPLEMENT of the GENERAL CONDITIONS as applicable.
- C. Payment for Differing Site Conditions: When rock excavation, as classified, is encountered, contract price and time will be adjusted in accordance with Articles, DIFFERING SITE CONDITIONS, CHANGES and CHANGES-SUPPLEMENT of the GENERAL CONDITIONS as applicable.

1.7 SUBMITTALS:

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Rock Excavation Report:
1. Certification of rock quantities excavated.
 2. Excavation method.

3/18/22

Fargo VA Medical Center
Fargo, North Dakota 58102

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11-09-21

3. Labor.
 4. Equipment.
 5. Land Surveyor's or Civil Engineer's name and official registration stamp.
 6. Plot plan showing elevation.
- C. Furnish to Contracting Officer's Representative:
1. Contactor shall furnish resumes with all personnel involved in the project including Project Manager, Superintendent, and on-site Engineer. Project Manager and Superintendent should have at least 3 years of experience on projects of similar size.
 2. Soil samples.
 - a. Classification in accordance with ASTM D2487 for each on-site or borrow soil material proposed for fill, backfill, engineered fill, or structural fill.
 - b. Laboratory compaction curve in accordance with ASTM D698 each on site or borrow soil material proposed for fill, backfill, engineered fill, or structural fill.
 - c. Test reports for compliance with ASTM D2940 requirements for subbase material.
 - d. Pre-excavation photographs and videotape in the vicinity of the existing structures to document existing site features, including surfaces finishes, cracks, or other structural blemishes that might be misconstrued as damage caused by earthwork operations.
 - e. The Contractor shall submit a scale plan daily that defines the location, limits, and depths of the area excavated.
 3. Contractor shall submit procedure and location for disposal of unused satisfactory material. Proposed source of borrow material. Notification of encountering rock in the project. Advance notice on the opening of excavation or borrow areas. Advance notice on shoulder construction for rigid pavements.

3/18/22

Fargo VA Medical Center
Fargo, North Dakota 58102

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11-09-21

1.8 APPLICABLE PUBLICATIONS:

A. Publications listed below form a part of this specification to extent referenced. Publications are referenced in text by basic designation only.

B. American Association of State Highway and Transportation Officials (AASHTO):

T99-10.....Standard Method of Test for Moisture-Density Relations of Soils Using a 2.5 kg (5.5 lb) Rammer and a 305 mm (12 inch) Drop

T180-10.....Standard Method of Test for Moisture-Density Relations of Soils using a 4.54 kg (10 lb) Rammer and a 457 mm (18 inch) Drop

C. American Society for Testing and Materials (ASTM):

C33-03.....Concrete Aggregate

D448-08.....Standard Classification for Sizes of Aggregate for Road and Bridge Construction

D698-07e1.....Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft. lbf/ft³ (600 kN m/m³))

D1140-00.....Amount of Material in Soils Finer than the No. 200 (75-micrometer) Sieve

D1556-07.....Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method

D1557-09.....Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2700 kN m/m³))

D2167-08.....Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method

3/18/22

Fargo VA Medical Center
Fargo, North Dakota 58102

EHRM Infrastructure Upgrades - Fargo ND

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11-09-21

- D2487-11.....Standard Classification of Soils for
Engineering Purposes (Unified Soil
Classification System)
- D2940-09.....Standard Specifications for Graded Aggregate
Material for Bases or Subbases for Highways or
Airports
- D6938-10.....Standard Test Method for In-Place Density and
Water Content of Soil and Soil-Aggregate by
Nuclear Methods (Shallow Depth)
- D. Society of Automotive Engineers (SAE):
- J732-07.....Specification Definitions - Loaders
- J1179-08.....Hydraulic Excavator and Backhoe Digging Forces

PART 2 - PRODUCTS

2.1 MATERIALS:

- A. General: Provide borrow soil material when sufficient satisfactory soil materials are not available from excavations.
- B. Fills: Material in compliance with ASTM D2487 Soil Classification Groups GW, GP, GM, SW, SP, SM, SC, and ML, or any combination of these groups; free of rock or gravel larger than 75 mm (3 inches) in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter. Material approved from on site or off site sources having a minimum dry density of 1760 kg/m³ (110 pcf), a maximum Plasticity Index of 15, and a maximum Liquid Limit of 40.
- C. Engineered Fill: Naturally or artificially graded mixture of compliance with ASTM D2487 Soil Classification Groups GW, GP, GM, SW, SP, SM, SC, and ML, or any combination of these groups, or as approved by the Engineer or material with at least 90 percent passing a 37.5-mm (1 1/2-inch) sieve and not more than 12 percent passing a 75-µm (No. 200) sieve, per ASTM D2940;.
- D. Bedding: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940; except

3/18/22

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11-09-21

with 100 percent passing a 25 mm (1 inch) sieve and not more than 8 percent passing a 75-µm (No. 200) sieve.

- E. Drainage Fill: Washed, narrowly graded mixture of crushed stone, or crushed or uncrushed gravel; ASTM D448; coarse-aggregate grading Size 57; with 100 percent passing a 37.5 mm (1 1/2-inch) sieve and 0 to 5 percent passing a 2.36 mm (No. 8) sieve.

F. Granular Fill:

1. Under concrete slab, - granular fill shall consist of clean, poorly graded crushed rock, crushed gravel, or uncrushed gravel placed beneath a building slab with or without a vapor barrier to cut off the capillary flow of pore water to the area immediately below. Fine aggregate grading shall conform to ASTM C 33 with a maximum of 3 percent by weight passing ASTM D 1140, 75 micrometers (No. 200) sieve, or 37.5 mm (1-1/2 inches) and no more than 2 percent by weight passing the 4.75 mm (No. 4) size sieve or coarse aggregate Size 57, 67, or 77.

2. Bedding for sanitary and storm sewer pipe, crushed stone or gravel graded from 13 mm (1/2 inch) to 4.75 mm (No 4), per ASTM D2940.

- G. Requirements for Offsite Soils: Offsite soils brought in for use as backfill shall be tested for TPH, BTEX and full TCLP including ignitability, corrosivity and reactivity. Backfill shall contain less than 100 parts per million (ppm) of total hydrocarbons (TPH) and less than 10 ppm of the sum of Benzene, Toluene, Ethyl Benzene, and Xylene (BTEX) and shall not fail the TCLP test. TPH concentrations shall be determined by using EPA 600/4-79/020 Method 418.1. BTEX concentrations shall be determined by using EPA SW-846.3-3a Method 5030/8020. TCLP shall be performed in accordance with EPA SW-846.3-3a Method 1311. Provide Borrow Site Testing for TPH, BTEX and TCLP from a composite sample of material from the borrow site, with at least one test from each borrow site.

- H. Buried Warning and Identification Tape: Polyethylene plastic and metallic core or metallic-faced, acid- and alkali-resistant

3/18/22

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11-09-21

polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3 inch minimum width, color coded as specific below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Color and printing shall be permanent, Unaffected by moisture or soil. Warning tape color codes:

Red:	Electric
Yellow:	Gas, Oil, Dangerous Materials
Orange:	Telephone and Other Communications
Blue:	Water Systems
Green:	Sewer Systems
White:	Steam Systems
Gray:	Compressed Air

- I. Warning Tape for Metallic Piping: Acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above. Minimum thickness of tape shall be 0.076 mm (0.003 inch). Tape shall have a minimum strength of 10.3 MPa (1500 psi) lengthwise, and 8.6 MPa (1250 psi) crosswise, with a maximum 350 percent elongation.
- J. Detectable Warning Tape for Non-Metallic Piping: Polyethylene plastic tape conforming to the width, color, and printing requirements specified above. Minimum thickness of the tape shall be 0.102 mm (0.004 inch). Tape shall have a minimum strength of 10.3 MPa (1500 psi) lengthwise and 8.6 MPa (1250 psi) crosswise. Tape shall be manufactured with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 0.9 m (3 feet) deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.
- K. Detection Wire For Non-Metallic Piping: Detection wire shall be Insulated single strand, solid copper with a minimum of 12 AWG.

3/18/22

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11-09-21

PART 3 - EXECUTION

3.1 SITE PREPARATION:

- A. Clearing: Clear within limits of earthwork operations as shown. Work includes removal of trees, shrubs, fences, foundations, incidental structures, paving, debris, trash, and other obstructions. Remove materials from Medical Center.
- B. Grubbing: Remove stumps and roots 75 mm (3 inch) and larger diameter. Undisturbed sound stumps, roots up to 75 mm (3 inch) diameter, and nonperishable solid objects a minimum of 900 mm (3 feet) below subgrade or finished embankment may be left.
- C. Trees and Shrubs: Trees and shrubs, not shown for removal, may be removed from areas within 4500 mm (15 feet) of new construction and 2250 mm (7.5 feet) of utility lines when removal is approved in advance by Contracting Officer's Representative. Remove materials from Medical Center. Trees and shrubs, shown to be transplanted, shall be dug with a ball of earth and burlapped in accordance with latest issue of, "American Standard for Nursery Stock" of the American Association of Nurserymen, Inc. Transplant trees and shrubs to a permanent or temporary position within two hours after digging. Maintain trees and shrubs held in temporary locations by watering as necessary and feeding semiannually with liquid fertilizer with a minimum analysis of 5 percent nitrogen, 10 percent phosphorus, and 5 percent potash. Maintain plants moved to permanent positions as specified for plants in temporary locations until conclusion of contract. Box, and otherwise protect from damage, existing trees and shrubs which are not shown to be removed in construction area. Immediately repair damage to existing trees and shrubs by trimming, cleaning and painting damaged areas, including roots, in accordance with standard industry horticultural practice for the geographic area and plant species. Do not store building materials closer to trees and shrubs, that are to remain, than farthest extension of their limbs.

3/18/22

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11-09-21

- D. Stripping Topsoil: Strip topsoil from within limits of earthwork operations as specified. Topsoil shall be a fertile, friable, natural topsoil of loamy character and characteristic of locality. Topsoil shall be capable of growing healthy horticultural crops of grasses. Stockpile topsoil and protect as directed by Contracting Officer's Representative. Eliminate foreign materials, such as weeds, roots, stones, subsoil, frozen clods, and similar foreign materials larger than 0.014 m³ (1/2 cubic foot) in volume, from soil as it is stockpiled. Retain topsoil on station. Remove foreign materials larger than 50 mm (2 inches) in any dimension from topsoil used in final grading. Topsoil work, such as stripping, stockpiling, and similar topsoil work shall not, under any circumstances, be carried out when soil is wet so that the composition of the soil will be destroyed.
- E. Concrete Slabs and Paving: Score deeply or saw cut to insure a neat, straight cut, sections of existing concrete slabs and paving to be removed where excavation or trenching occurs. Extend pavement section to be removed a minimum of 300 mm (12 inches) on each side of widest part of trench excavation and insure final score lines are approximately parallel unless otherwise indicated. Remove material from Medical Center.
- F. Lines and Grades: Registered Professional Land Surveyor or Registered Civil Engineer, specified in Section 01 00 00, GENERAL REQUIREMENTS, shall establish lines and grades.
1. Grades shall conform to elevations indicated on plans within the tolerances herein specified. Generally, grades shall be established to provide a smooth surface, free from irregular surface changes. Grading shall comply with compaction requirements and grade cross sections, lines, and elevations indicated. Where spot grades are indicated the grade shall be established based on interpolation of the elevations between the spot grades while maintaining appropriate transition at structures and paving and uninterrupted drainage flow into inlets.

3/18/22

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11-09-21

2. Locations of existing and proposed elevations indicated on plans, except spot elevations, are approximate and are from a site survey that measured spot elevations and subsequently generated existing contours and spot elevations. Proposed spot elevations and contour lines have been developed utilizing the existing conditions survey and developed contour lines and may be approximate. Contractor is responsible to notify Contracting Officer's Representative of any differences between existing elevations shown on plans and those encountered on site by Surveyor/Engineer described above. Notify Contracting Officer's Representative of any differences between existing or constructed grades, as compared to those shown on the plans.
 3. Subsequent to establishment of lines and grades, Contractor will be responsible for any additional cut and/or fill required to ensure that site is graded to conform to elevations indicated on plans.
 4. Finish grading is specified in Section 32 90 00, PLANTING.
- G. Disposal: All materials removed from the property shall be disposed of at a legally approved site, for the specific materials, and all removals shall be in accordance with all applicable Federal, State and local regulations.

3.2 EXCAVATION:

- A. Shoring, Sheet piling and Bracing: Shore, brace, or slope, its angle of repose or to an angle considered acceptable by the Contracting Officer's Representative, banks of excavations to protect workmen, banks, adjacent paving, structures, and utilities.
1. Design of the temporary support of excavation system is the responsibility of the Contractor. The Contractor shall submit a Shoring and Sheet piling plan for approval 15 days prior to starting work. Submit drawings and calculations, certified by a registered professional engineer, describing the methods for shoring and sheet piling of excavations. Shoring, including sheet piling, shall be furnished and installed as necessary to protect workmen, banks,

3/18/22

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11-09-21

- adjacent paving, structures, and utilities. Shoring, bracing, and sheeting shall be removed as excavations are backfilled, in a manner to prevent caving.
2. Construction of the support of excavation system shall not interfere with the permanent structure and may begin only after a review by the Contracting Officer's Representative.
 3. Extend shoring and bracing to a minimum of 1500 mm (5 feet) below the bottom of excavation. Shore excavations that are carried below elevations of adjacent existing foundations.
 4. If bearing material of any foundation is disturbed by excavating, improper shoring or removal of existing or temporary shoring, placing of backfill, and similar operations, the Contractor shall underpin the existing foundation, per Section 3.3 provide a concrete fill support in compliance with specifications Section 31 23 23.33, FLOWABLE FILL, under disturbed foundations, as directed by Contracting Officer's Representative, at no additional cost to the Government. Do not remove shoring until permanent work in excavation has been inspected and approved by Contracting Officer's Representative.
 5. The Contractor is required to hire a Professional Geotechnical Engineer to provide inspection of excavations and soil/groundwater conditions throughout construction. The Geotechnical Engineer shall be responsible for performing pre-construction and periodic site visits throughout construction to assess site conditions. The Geotechnical Engineer shall update the excavation, sheeting and dewatering plans as construction progresses to reflect changing conditions and shall submit an updated plan if necessary. A written report shall be submitted, at least monthly, informing the Contractor and Contracting Officer's Representative of the status of the plan and an accounting of the Contractor's adherence to the plan addressing any present or potential problems. The Geotechnical

3/18/22

EHRM Infrastructure Upgrades - Fargo ND

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11-09-21

- Engineer shall be available to meet with the Contracting Officer's Representative at any time throughout the contract duration.
- B. Excavation Drainage: Operate pumping equipment, and/or provide other materials, means and equipment as required to keep excavation free of water and subgrade dry, firm, and undisturbed until approval of permanent work has been received from Contracting Officer's Representative. Approval by the Contracting Officer's Representative is also required before placement of the permanent work on all subgrades. Groundwater flowing toward or into excavations shall be controlled to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. French drains, sumps, ditches or trenches will not be permitted within 0.9 m (3 feet) of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made. Control measures shall be taken by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. While the excavation is open, the water level shall be maintained continuously, at least 3feet below the working level. Operate dewatering system continuously until construction work below existing water levels is complete. Submit performance records weekly. Measure and record performance of dewatering system at same time each day by use of observation wells or piezometers installed in conjunction with the dewatering system. Relieve hydrostatic head in pervious zones below subgrade elevation in layered soils to prevent uplift.
- C. Subgrade Protection: Protect subgrades from softening, undermining, washout, or damage by rain or water accumulation. Reroute surface water runoff from excavated areas and not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches. When subgrade for foundations has been disturbed by water, remove disturbed material to firm undisturbed material after water is

3/18/22

EHRM Infrastructure Upgrades - Fargo ND

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11-09-21

brought under control. Replace disturbed subgrade in trenches with concrete or material approved by the Contracting Officer's Representative.

D. Proofrolling:

1. After rough grade has been established in cut areas and prior to placement of fill in fill areas under building and pavements, proofroll exposed subgrade with a fully loaded dump truck to check for pockets of soft material.
2. Proof rolling shall be done on an exposed subgrade free of surface water (wet conditions resulting from rainfall) which would promote degradation of an otherwise acceptable subgrade. After stripping, proof roll the existing subgrade with six passes of a dump truck loaded with 6 cubic meters (4 cubic yards) of soil 13.6 metric tons (15 ton), pneumatic-tired roller. Operate the roller or truck in a systematic manner to ensure the number of passes over all areas, and at speeds between 4 to 5.5 km/hour (2 1/2 to 3 1/2 mph). When proof rolling, one-half of the passes made with the roller shall be in a direction perpendicular to the other passes. Notify the Contracting Officer's Representative a minimum of 3 days prior to proof rolling. Proof rolling shall be performed in the presence of the Contracting Officer's Representative. Rutting or pumping of material shall be undercut as directed by the Contracting Officer's Representative. Maintain subgrade until succeeding operation has been accomplished.

E. Building Earthwork:

1. Excavation shall be accomplished as required by drawings and specifications.
2. Excavate foundation excavations to solid undisturbed subgrade.
3. Remove loose or soft materials to a solid bottom.
4. Fill excess cut under footings or foundations with 25 MPa (3000 psi) concrete poured separately from the footings.
5. Do not tamp earth for backfilling in footing bottoms, except as specified.

3/18/22

EHRM Infrastructure Upgrades - Fargo ND

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11-09-21

6. Slope grades to direct water away from excavations and to prevent ponding.
7. Capillary water barrier (granular fill) under concrete floor and area-way slabs on grade shall be placed directly on the subgrade and shall be compacted with a minimum of two passes of a hand-operated plate-type vibratory compactor.
8. Ensure that footing subgrades have been inspected and approved by the Contracting Officer's Representative prior to concrete placement. Excavate to bottom of pile cap prior to placing or driving piles, unless authorized otherwise by the Contracting Officer's Representative. Backfill and compact over excavations and changes in grade due to pile driving operations to 95 percent of ASTM D698 maximum density.

F. Trench Earthwork:

1. Utility trenches (except sanitary and storm sewer):
 - a. Excavate to a width as necessary for sheeting and bracing and proper performance of the work.
 - b. Grade bottom of trenches with bell holes scooped out to provide a uniform bearing.
 - c. Support piping on suitable undisturbed earth unless a mechanical support is shown. Unstable material removed from the bottom of the trench or excavation shall be replaced with select granular material placed in layers not exceeding 150 mm (6 inches) loose thickness.
 - d. Length of open trench in advance of piping laying shall not be greater than is authorized by Contracting Officer's Representative.
 - e. Provide buried utility lines with utility identification tape. Bury tape 300 mm (12 inches) below finished grade; under pavements and slabs, bury tape 150 mm (6 inches) below top of subgrade

3/18/22

EHRM Infrastructure Upgrades - Fargo ND

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11-09-21

- f. Bury detection wire directly above non-metallic piping at a distance not to exceed 300 mm (12 inches) above the top of pipe. The wire shall extend continuously and unbroken, from manhole to manhole. The ends of the wire shall terminate inside the manholes at each end of the pipe, with a minimum of 0.9 m (3 feet) of wire, coiled, remaining accessible in each manhole. The wire shall remain insulated over its entire length. The wire shall enter manholes between the top of the corbel and the frame, and extend up through the chimney seal between the frame and the chimney seal. For force mains, the wire shall terminate in the valve pit at the pump station end of the pipe.
- g. Bedding shall be of the type and thickness shown. Initial backfill material shall be placed and compacted with approved tampers to a height of at least one foot above the utility pipe or conduit. The backfill shall be brought up evenly on both sides of the pipe for the full length of the pipe. Care shall be taken to ensure thorough compaction of the fill under the haunches of the pipe. Except as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with AWWA C600, Type 4, except as specified herein. Backfill to top of pipe shall be compacted to 95 percent of ASTM D 698 maximum density. Plastic piping shall have bedding to spring line of pipe. Provide materials as follows:
- 1) Class I: Angular, 6 to 40 mm (0.25 to 1.5 inches), graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, and crushed shells.
 - 2) Class II: Coarse sands and gravels with maximum particle size of 40 mm (1.5 inches), including various graded sands and gravels containing small percentages of fines, generally granular and non-cohesive, either wet or dry. Soil Types GW,

3/18/22

EHRM Infrastructure Upgrades - Fargo ND

Bancroft Architects + Engineers

11-09-21

GP, SW, and SP are included in this class as specified in ASTM D2487.

2. Sanitary and storm sewer trenches:

- a. Trench width below a point 150 mm (6 inches) above top of pipe shall be 600 mm (24 inches) maximum for pipe up to and including 300 mm (12 inches) diameter, and four-thirds diameter of pipe plus 200 mm (8 inches) for pipe larger than 300 mm (12 inches). Width of trench above that level shall be as necessary for sheeting and bracing and proper performance of the work.
 - 1) Bed bottom quadrant of pipe on suitable undisturbed soil or granular fill. Unstable material removed from the bottom of the trench or excavation shall be replaced with select granular material placed in layers not exceeding 150 mm (6 inches) loose thickness.1) Undisturbed: Bell holes shall be no larger than necessary for jointing. Backfill up to a point 300 mm (12 inches) above top of pipe shall be clean earth placed and tamped by hand.
 - 2) Granular Fill: Depth of fill shall be a minimum of 75 mm (3 inches) plus one sixth of pipe diameter below pipe to 300 mm (12 inches) above top of pipe. Place and tamp fill material by hand.
- c. Place and compact as specified remainder of backfill using acceptable excavated materials. Do not use unsuitable materials.
- d. Use granular fill for bedding where rock or rocky materials are excavated.
- e. Provide buried utility lines with utility identification tape. Bury tape 300 mm (12 inches) below finished grade; under pavements and slabs, bury tape 150 mm (6 inches) below top of subgrade
- f. Bury detection wire directly above non-metallic piping at a distance not to exceed 300 mm (12 inches) above the top of pipe. The wire shall extend continuously and unbroken, from manhole to

3/18/22

EHRM Infrastructure Upgrades - Fargo ND

Bancroft Architects + Engineers

11-09-21

manhole. The ends of the wire shall terminate inside the manholes at each end of the pipe, with a minimum of 0.9 m (3 feet) of wire, coiled, remaining accessible in each manhole. The wire shall remain insulated over its entire length. The wire shall enter manholes between the top of the corbel and the frame, and extend up through the chimney seal between the frame and the chimney seal. For force mains, the wire shall terminate in the valve pit at the pump station end of the pipe.

- g. Bedding shall be of the type and thickness shown. Initial backfill material shall be placed and compacted with approved tampers to a height of at least one foot above the utility pipe or conduit. The backfill shall be brought up evenly on both sides of the pipe for the full length of the pipe. Care shall be taken to ensure thorough compaction of the fill under the haunches of the pipe. Except as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with AWWA C600, Type 4, except as specified herein. Backfill to top of pipe shall be compacted to 95 percent of ASTM D698 maximum density. Plastic piping shall have bedding to spring line of pipe. Provide materials as follows:

- 1) Class I: Angular, 6 to 40 mm (0.25 to 1.5 inches), graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, and crushed shells.
- 2) Class II: Coarse sands and gravels with maximum particle size of 40 mm (1.5 inches), including various graded sands and gravels containing small percentages of fines, generally granular and non-cohesive, either wet or dry. Soil Types GW, GP, SW, and SP are included in this class as specified in ASTM D2487.

- G. Site Earthwork: Earth excavation includes excavating pavements and obstructions visible on surface; underground structures, utilities, and

3/18/22

EHRM Infrastructure Upgrades - Fargo ND

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11-09-21

other items indicated to be removed; together with soil, boulders, and other materials not classified as rock or unauthorized excavation. Excavation shall be accomplished as required by drawings and specifications. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 25 mm (1 inch). Extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, complying with OSHA requirements, and for inspections. Remove subgrade materials that are determined by Contracting Officer's Representative as unsuitable, and replace with acceptable material. If there is a question as to whether material is unsuitable or not, the contractor shall obtain samples of the material, under the direction of the Contracting Officer's Representative, and the materials shall be examined by an independent testing laboratory for soil classification to determine whether it is unsuitable or not. Testing of the soil shall be performed by the VA Testing Laboratory. When unsuitable material is encountered and removed, contract price and time will be adjusted in accordance with Articles, DIFFERING SITE CONDITIONS, CHANGES and CHANGES-SUPPLEMENT of the GENERAL CONDITIONS as applicable. Adjustments to be based on volume in cut section only.

1. Site Grading:

- a. Provide a smooth transition between adjacent existing grades and new grades.
- b. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
- c. Slope grades to direct water away from buildings and to prevent ponds from forming where not designed. Finish subgrades to required elevations within the following tolerances:
 - 1) Lawn or Unpaved Areas: Plus or minus 25 mm (1 inch).
 - 2) Walks: Plus or minus 25 mm (1 inch).
 - 3) Pavements: Plus or minus 13 mm (1 inch).

3/18/22

EHRM Infrastructure Upgrades - Fargo ND

Bancroft Architects + Engineers

11-09-21

- d. Grading Inside Building Lines: Finish subgrade to a tolerance of 13 mm (1/2 inch) when tested with a 3000 mm (10 foot) straightedge.

3.3 UNDERPINNING:

- A. Design of the underpinning system is the responsibility of the Contractor and should be designed by a registered professional engineer and is subject to review and approval by the Contracting Officer's Representative. Underpinning of existing building foundations, as indicated on structural drawings, or where excavation undermines existing foundations, shall be accomplished in the following manner:
1. Make general excavation for new construction, where new foundations are to be below existing foundations, to elevation of new foundations (or sized stone subbase), maintaining a 45 degree sloped berm.
 2. For underpinning pits, underpin existing wall foundations by excavating 1200 mm (4 feet) wide pits to depth shown on drawings skipping 3 sections at any one time so as to maintain support for wall at all times.
 3. Underpin intervening sections one at a time; no adjacent sections shall be underpinned until concrete in adjacent sections shall have reached 20 MPa (2500 psi) strength and have been dry packed with non-shrink grout to obtain positive bearing. Sheet and brace underpinning pits if soil will not stand on a vertical cut during this operation, or as required for safety of workmen. Repack any voids behind sheeting to prevent sloughing which could cause settlement of existing foundations. Contractor performing this portion of work shall have been prequalified by Contracting Officer's Representative as having previously performed successfully this type of work or will demonstrate his capability for successfully performing this work. It shall be sole responsibility of the Contractor to guard against objectionable movement or settlement and to preserve integrity of existing structures.

3/18/22

EHRM Infrastructure Upgrades - Fargo ND

Bancroft Architects + Engineers

11-09-21

4. The tip elevation of the underpinning pits shall be a minimum of 900 mm (3 feet) below the adjacent excavation elevation.
5. Subgrades at the tip of the underpinning pit shall be clean, dry, and free of debris and shall be observed by the Contracting Officer's Representative prior to concrete placement.
6. Concrete shall not be free fall greater than 3000 mm (10 feet) into the pit.

3.4 FILLING AND BACKFILLING:

- A. General: Do not fill or backfill until all debris, water, unsatisfactory soil materials, obstructions, and deleterious materials have been removed from excavation. For fill and backfill, use excavated materials and borrow meeting the criteria specified herein, as applicable. Borrow will be supplied at no additional cost to the Government. Do not use unsuitable excavated materials. Do not backfill until foundation walls have been completed above grade and adequately braced, waterproofing or dampproofing applied, foundation drainage, and pipes coming in contact with backfill have been installed and work inspected and approved by Contracting Officer's Representative.
- B. Placing: Place materials in horizontal layers not exceeding 200 mm (8 inches) in loose depth for material compacted by heavy compaction equipment, and not more than 100 mm (4 inches) in loose depth for material compacted by hand-operated tampers and then compacted. Place backfill and fill materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure. Place no material on surfaces that are muddy, frozen, or contain frost.
- C. Compaction: Compact with approved tamping rollers, sheepfoot rollers, pneumatic tired rollers, steel wheeled rollers, vibrator compactors, or other approved equipment (hand or mechanized) well suited to soil being compacted. Do not operate mechanized vibratory compaction equipment within 3000 mm (10 feet) of new or existing building walls without prior approval of Contracting Officer's Representative. Moisten or

3/18/22

EHRM Infrastructure Upgrades - Fargo ND

Bancroft Architects + Engineers

11-09-21

aerate material as necessary to provide moisture content that will readily facilitate obtaining specified compaction with equipment used. Backfill adjacent to any and all types of structures shall be placed and compacted to at least 90 percent laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials to prevent wedging action or eccentric loading upon or against the structure. Compact soil to not less than the following percentages of maximum dry density, according to ASTM D698 or ASTM D1557 as specified below:

1. Fills, Embankments, and Backfill

- a. Under proposed structures, building slabs, steps, and paved areas, scarify and recompact top 300 mm (12 inches) of existing subgrade and each layer of backfill or fill material in accordance with ASTM D698 95 percent.
- b. Curbs, curbs and gutters, ASTM D698 95 percent.
- c. Under Sidewalks, scarify and recompact top 150 mm (6 inches) below subgrade and compact each layer of backfill or fill material in accordance with ASTM D698 95 percent.
- d. Landscaped areas, top 400 mm (16 inches), ASTM D698 85 percent.
- e. Landscaped areas, below 400 mm (16 inches) of finished grade, ASTM D698 90 percent.

2. Natural Ground (Cut or Existing)

- a. Under building slabs, steps and paved areas, top 150 mm (6 inches), ASTM D698 95 percent.
- b. Curbs, curbs and gutters, top 150 mm (6 inches), shall be constructed per geotechnical report recommendations.
- c. Under sidewalks, top 150 mm (6 inches), shall be constructed per geotechnical report recommendations.
- D. Borrow Material: Borrow material shall be selected to meet the requirements and conditions of the particular fill or embankment for which it is to be used. Borrow material shall be obtained from the borrow areas shown on drawings within the limits of the

3/18/22

EHRM Infrastructure Upgrades - Fargo ND

Bancroft Architects + Engineers

11-09-21

project site, selected by the Contractor or from approved private sources Unless otherwise provided in the contract, the Contractor shall obtain from the owners the right to procure material, pay royalties and other charges involved, and bear the expense of developing the sources, including rights-of-way for hauling. Borrow material from approved sources on Government-controlled land may be obtained without payment of royalties. Unless specifically provided, no borrow shall be obtained within the limits of the project site without prior written approval. Necessary clearing, grubbing, and satisfactory drainage of borrow pits and the disposal of debris thereon shall be considered related operations to the borrow excavation.

- E. Opening and Drainage of Excavation and Borrow Pits: The Contractor shall notify the Contracting Officer's Representative sufficiently in advance of the opening of any excavation or borrow pit to permit elevations and measurements of the undisturbed ground surface to be taken. Except as otherwise permitted, borrow pits and other excavation areas shall be excavated providing adequate drainage. Overburden and other spoil material shall be transported to designated spoil areas or otherwise disposed of as directed. Borrow pits shall be neatly trimmed and drained after the excavation is completed. The Contractor shall ensure that excavation of any area, operation of borrow pits, or dumping of spoil material results in minimum detrimental effects on natural environmental conditions.

3.5 GRADING:

- A. General: Uniformly grade the areas within the limits of this section, including adjacent transition areas. Smooth the finished surface within specified tolerance. Provide uniform levels or slopes between points where elevations are indicated, or between such points and existing finished grades. Provide a smooth transition between abrupt changes in slope.

3/18/22

EHRM Infrastructure Upgrades - Fargo ND

Bancroft Architects + Engineers

11-09-21

- B. Cut rough or sloping rock to level beds for foundations. In pipe spaces or other unfinished areas, fill low spots and level off with coarse sand or fine gravel.
- C. Slope backfill outside building away from building walls for a minimum distance of 1800 mm (6 feet).
- D. Finish grade earth floors in pipe basements as shown to a level, uniform slope and leave clean.
- E. Finished grade shall be at least 150 mm (6 inches) below bottom line of window or other building wall openings unless greater depth is shown.
- F. Place crushed stone or gravel fill under concrete slabs on grade, tamped, and leveled. Thickness of fill shall be 150 mm (6 inches) unless otherwise shown.
- G. Finish subgrade in a condition acceptable to Contracting Officer's Representative at least one day in advance of paving operations. Maintain finished subgrade in a smooth and compacted condition until succeeding operation has been accomplished. Scarify, compact, and grade subgrade prior to further construction when approved compacted subgrade is disturbed by Contractor's subsequent operations or adverse weather.
- H. Grading for Paved Areas: Provide final grades for both subgrade and base course to +/- 6 mm (0.25 inches) of indicated grades.

3.6 DISPOSAL OF UNSUITABLE AND EXCESS EXCAVATED MATERIAL:

- A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Medical Center property.
- B. Disposal: Transport surplus satisfactory soil to designated storage areas on Medical Center property. Stockpile or spread soil as directed by Contracting Officer's Representative.
 - 1. Remove waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Medical Center property.
- C. Place excess excavated materials suitable for fill and/or backfill on site where directed.

3/18/22

Fargo VA Medical Center
Fargo, North Dakota 58102

EHRM Infrastructure Upgrades - Fargo ND

Bancroft Architects + Engineers

11-09-21

- D. Remove from site and dispose of any excess excavated materials after all fill and backfill operations have been completed.
- E. Segregate all excavated contaminated soil designated by the Contracting Officer's Representative from all other excavated soils, and stockpile on site on two 0.15 mm (6 mil) polyethylene sheets with a polyethylene cover. A designated area shall be selected for this purpose. Dispose of excavated contaminated material in accordance with State and Local requirements.

3.7 CLEAN UP:

Upon completion of earthwork operations, clean areas within contract limits, remove tools, and equipment. Provide site clear, clean, free of debris, and suitable for subsequent construction operations. Remove all debris, rubbish, and excess material from Medical Center property.

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3/18/22

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

SECTION 31 23 00
EXCAVATION AND FILL

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Excavation and/or embankment from existing ground to subgrade, including soil sterilant, for roadways, driveways, parking areas, walks, paths, or trails and any other site improvements called for on the Plans.

1.02 SECTION EXCLUDES

- A. Earthwork related to underground utility installation, see Section 31 23 33 – Trenching and Backfilling.

1.03 RELATED DOCUMENTS

A. ASTM:

- 1. D 1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort.
- 2. D 1586, Method for Penetration Tests and Split-Barrel Sampling of Soils.
- 3. D 2487, Classification of Soils for Engineering Purposes.
- 4. D 3740, Practice for Evaluation of Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction.
- 5. D 4318. Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils.
- 6. E 329, Specification for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction.
- 7. E 548, Guide for General Criteria Used for Evaluating Laboratory Competence.

B. International Building Code:

- 1. Chapter 11B – Accessibility to Public Buildings.
- 2. Chapter 33 – Site Work, Demolition and Construction.

C. Caltrans Standard Specifications:

- 1. Section 10-6, Watering.
- 2. Section 19, Earthwork.

D. OSHA, Title 8.

1.04 DEFINITIONS

Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft-AE Project No. 22-113

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- A. Borrow: Approved soil material imported from off-site for use as Structural Fill or Backfill.
- B. Excavation: Removal of material encountered above subgrade elevations.
 - 1. Authorized Over-Excavation: Excavation below subgrade elevations or beyond indicated horizontal dimensions as shown on plans.
 - 2. Unauthorized Over-Excavation: Excavation below subgrade elevations or beyond indicated horizontal dimensions. Unauthorized excavation shall be without additional compensation.
- C. Structural Backfill: Soil materials used to fill excavations resulting from removal of existing below grade facilities, including trees. Any fill soil or aggregate base or crush rock under the building shall not contain recycled asphalt, asphalt grindings, or soil with petroleum products. See Section 31 23 33 – Trenching and Backfilling.
- D. Structural Fill: Soil materials used to raise existing grades.
- E. Rock: Rock material in beds, ledges, unstratified masses, and conglomerate deposits and boulders of rock material $\frac{3}{4}$ -cubic yards or more in volume that, according to ASTM D 1586, exceeds a standard penetration resistance of 100 blows/2-inches.
- F. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man made stationary features constructed above or below grade.
- G. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, base or topsoil materials.
- H. Unsuitable Material: Any soil material that is not suitable for a specific use on the Project.
- I. Utilities: onsite underground pipes, conduits, ducts and cables.

1.05 SUBMITTALS

- A. Follow submittal procedures outlined in Section 01 33 00 – Submittal Procedures.
- B. Submit material certificates signed by the material producer and the Contractor, certifying that that each material item complies with, or exceeds the specified requirements.

1.06 QUALITY ASSURANCE

- A. Conform all work to the appropriate portion(s) of the Code of Regulations, Title 24 and Standard Specifications, Sections 17 and 19.
- B. Percentage of compaction specified shall be the minimum acceptable. The percentage represents the ratio of the dry density of the compacted material to the maximum dry density of the material as determined by the procedure set forth in ASTM D 1557.
- C. Upon completion of the construction work, certify that all compacted fills and foundations are in place at the correct locations, and have been constructed in accordance with sound construction practice. In addition, certify that the materials used are of the types, quality and quantity required

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

by these Technical Specifications. The Contractor shall be responsible for the stability of all fills and backfills constructed by his forces.

- D. Finish soil grade tolerance at completion of grading:
 - 1. Building and paved areas: +0.05
 - 2. Other areas: ± 0.10 feet.
- E. The project geotechnical engineer shall be notified of the construction schedule at least one week prior to the beginning of major site construction, and notified at least 48 hours (working days) before being required to perform field observation and testing.

1.07 PROJECT CONDITIONS

- A. Promptly notify the Owner of surface or subsurface conditions differing from those disclosed in the construction documents. First notify the Owner verbally to permit verification and extent of condition and then in writing. No claim for conditions differing from those anticipated in the Contract Documents will be allowed unless the Contractor has notified the Owner in writing of differing conditions prior to the Contractor starting work on affected items.
- B. Protect open excavations, trenches, and the like with fences, covers and railings to maintain safe pedestrian and vehicular traffic passage.
- C. Prevent erosion of freshly graded areas during construction and until such time as permanent drainage and erosion control measures have been installed.
- D. Temporarily stockpile fill material in an orderly and safe manner and in a location approved by the Owner.
- E. Provide dust and noise control in conformance with Division 1 General Requirements for Cleaning and Waste Management.
- F. Environmental Requirements: When unfavorable weather conditions necessitate interrupting earthwork operation, areas shall be prepared by compaction of surface and grading to avoid collection of water. Provide adequate temporary drainage to prevent erosion. After interruption, compaction specified in last layer shall be re-established before resuming work.

PART 2 - PRODUCTS

2.01 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from on-site excavations.
- B. On-Site Structural Fill and Structural Backfill: Soil or soil-rock mixture from on site excavations, free from organic matter or other deleterious substances. On-site structural fill and backfill shall not contain rocks or rock fragments over 4 inches in greatest dimension and not more than 15

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

percent shall be over 2-1/2 inches in greatest dimension and with an organic content less than 3.0 percent by weight.

- C. Imported Structural Fill and Structural Backfill: Conform to the requirements of on-site structural fill. Material shall also be a non-expansive and predominantly granular soil or soil-rock mixture with plasticity index of 15 or less in accordance with ASTM D 4318 and an R-Value of 25 or greater.

PART 3 - EXECUTION

3.01 GENERAL

- A. Conform to Section 19, Earthwork, Standard Specifications as modified by the Contract Documents.
- B. Placement and compaction of material by flooding, ponding, or jetting will not be permitted.
- C. The use of explosives will not be permitted.

3.02 CONTROL OF WATER AND DEWATERING

- A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding the site and surrounding area. Provide dewatering equipment necessary to drain and keep excavations and site free from water.
- B. Dewater during backfilling operation so that groundwater is maintained a least one foot below level of compaction effort.
- C. Obtain the Owner's approval for proposed control of water and dewatering methods.
- D. Protect subgrades from softening, undermining, washout and damage by rain or water accumulation.
- E. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations.
- F. Maintain dewatering system in place until dewatering is no longer required.

3.03 WET WEATHER CONDITIONS

- A. Do not prepare subgrade, place or compact soil materials if above optimum moisture content.

3.04 BRACING AND SHORING

- A. Conform to Federal OSHA requirements.
- B. Place and maintain such bracing and shoring as may be required to support the sides of the excavations for the proper protection of workmen; to facilitate the work; to prevent damage to the facility being constructed; and to prevent damage to adjacent structures or facilities. Remove all bracing and shoring upon completion of the work.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- C. Be solely responsible for all bracing and shoring and, if requested by the Owner, submit details and calculations to the Owner. The Owner may forward the submittal to the Consulting Engineer and/or the California Division of Industrial Safety for their review. The Contractor's submittal shall include the basic design, assumed soils conditions and estimation of forces to be resisted, together with plans and specifications of the materials and methods to be used, and shall be prepared by a civil engineer or structural engineer. No excavations related to the proposed facility shall precede a response to the submittal by the Owner.
- D. Be solely responsible for installing and extracting the sheathing in a manner which will not disturb the position or operation of the facility being constructed or adjacent utilities and facilities.

3.05 EXCAVATION

- A. Excavate earth and rock to lines and grades shown on drawings and to the neat dimensions indicated on the Plans, required herein or as required to satisfactorily compact backfill.
- B. Remove and dispose of large rocks, pieces of concrete and other obstructions encountered during excavation.
- C. Where forming is required, excavate only as much material as necessary to permit placing and removing forms.
- D. Provide supports, shoring and sheet piles required to support the sides of excavations or for protection of adjacent existing improvements.

3.06 REMOVAL OF EXISTING FILLS AND UNSUITABLE MATERIAL

- A. Over-excavate areas of existing fills and other unsuitable material encountered during mass grading.
- B. Compensation for increased removal widths and depths that are not required will not be considered, except when such increase is necessary for protection of life and property as determined by and approved by the Owner.

3.07 GRADING

- A. Uniformly grade the Project to the elevations shown on plans.
- B. Finish ditches, gutters and swales to the sections, lines and grades indicated and to permit proper surface drainage.
- C. Round tops and bottoms of slopes as indicated or to blend with existing contours.

3.08 SUBGRADE PREPARATION

- A. Install underground utilities and service connections prior to final preparation of subgrade and placement of base materials for final surface facilities. Extend services so that final surface facilities are not disturbed when service connections are made.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- B. Prepare subgrades under paved areas, curbs, gutters, walks, structures, other surface facilities and areas to receive structural fill.
- C. Prepare subgrades for paved areas, curbs and gutters by plowing or scarifying surface at least 6 inches below final subgrade elevations and 5-feet beyond edge of pavement. Uniformly moisture condition to obtain optimum moisture contents. Break clods and condition surface by harrowing or dry rolling. Remove boulders, hard ribs and solid rock. Prepare earth uniform for full depth and width of subgrade.
- D. Protect utilities from damage during compaction of subgrades and until placement of final pavements or other surface facilities.

3.09 PLACEMENT OF STRUCTURAL FILL

- A. Place structural fill on prepared subgrade.
- B. Spread structural fill material in uniform lifts not more than 8-inches in un-compacted thickness and compact.
- C. Place structural fill material to suitable elevations above grade to provide for anticipated settlement and shrinkage.
- D. Overbuild fill slopes to obtain required compaction. Remove excess material to lines and grades indicated.
- E. Do not drop fill on structures. Do not backfill around, against or upon concrete or masonry structures until structure has attained sufficient strength to withstand loads imposed and the horizontal structural system had been installed.
- F. Backfill in uniform lifts not exceeding 8 inches in uncompacted thickness. Each lift should be brought to a uniform moisture content of at least 1 percent above optimum prior to compacting by either spraying the soil with water if it is too dry or aerating the material if it is too wet.

3.10 LOT FINISH GRADING

- A. Blade finish lots to lines and grades indicated.

3.11 COMPACTION AND TESTING

- A. Do not compact by ponding, flooding or jetting.
- B. Compact soils at optimum water content. Aerate material if it is too wet. Add water to material if it is too dry. Thoroughly mix lifts before compaction to ensure uniform moisture distribution.
- C. Perform compaction using rollers, pneumatic or vibratory compactors.
- D. Compaction requirements:
 - 1. Compact structural fills less than 5-feet thick to 90 percent compaction.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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2. Compact structural fill 5-feet thick or greater to 95 percent compaction.
3. Compact the upper 6 inches of subgrade soils beneath pavements, curbs and gutters to 95 percent compaction. Extend compaction 5-feet beyond pavement.
4. Compact the upper 6-inches of subgrade soils to the following percentage of compaction: 95 percent under walks and pavements; 93 percent for foundations; and 90 percent for areas to receive structural fill."

3.12 DISPOSAL

- A. Lawfully dispose of all unsuitable and excess or surplus material off-site at no cost to the Owner.

END OF SECTION

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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SECTION 31 23 33
TRENCHING AND BACKFILLING

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Excavation, bedding, and backfill for underground storm drain, sanitary sewer, and water piping and associated structures.

1.02 SECTION EXCLUDES

- A. Drainage fill material and placement around subdrains.
- B. Trenching and backfill for other utilities such as underground HVAC piping, electrical conduit, telephone conduit, gas piping, cable TV conduit, etc.

1.03 RELATED DOCUMENTS

A. ASTM:

- 1. C 33, Specification for Concrete Aggregates.
- 2. C 150, Specification for Portland Cement.
- 3. C 260, Specification for Air-Entraining Admixtures for Concrete.
- 4. C 618, Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.
- 5. D 1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort.
- 6. D 2321, Practice for Underground Installation of Flexible Thermoplastic Sewer Pipe.
- 7. D 2487, Classification of Soils for Engineering Purposes.
- 8. D 3740, Practice for Evaluation of Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction.
- 9. E 329, Specification for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction.
- 10. E 548, Guide for General Criteria Used for Evaluating Laboratory Competence.

B. International Building Code:

- 1. Chapter 11B – Accessibility to Public Buildings.
- 2. Chapter 33 – Site Work, Demolition and Construction.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

C. Standard Specifications:

1. Section 19, Earthwork.
2. Section 26, Aggregate Bases.
3. Section 68, Subsurface Drains.
4. Section 88, Engineering Fabrics.

1.04 DEFINITIONS

- A. AC: Asphalt Concrete.
- B. ASTM: American Society for Testing and Materials.
- C. Bedding: Material from bottom of trench to bottom of pipe.
- D. CDF: Controlled Density Fill.
- E. DIP: Ductile Iron Pipe.
- F. Initial Backfill: Material from bottom of pipe to 12-inches above top of pipe.
- G. PCC: Portland Cement Concrete.
- H. RCP: Reinforced Concrete Pipe.
- I. Springline of Pipe: Imaginary line on surface of pipe at a vertical distance of $\frac{1}{2}$ the outside diameter measured from the top or bottom of the pipe.
- J. Subsequent Backfill: Material from 12-inches above top of pipe to subgrade of surface material or subgrade of surface facility or to finish grade.
- K. Trench Excavation: Removal of material encountered above subgrade elevations and within horizontal trench dimensions.
 1. Authorized Trench Over-Excavation: Excavation below trench subgrade elevations or beyond indicated horizontal trench dimensions as shown on plans.
 2. Unauthorized Trench Over-Excavation: Excavation below trench subgrade elevations or beyond indicated horizontal trench dimensions. Unauthorized excavation shall be without additional compensation.
- L. Utility Structures:
 1. Storm drainage manholes, catch basins, drop inlets, curb inlets, vaults, etc.
 2. Sanitary sewer manholes, vaults, etc.
 3. Water vaults, etc.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

1.05 SUBMITTALS

- A. Follow submittal procedures outlined in Section 01 33 00 – Submittal Procedures.
- B. Product Data:
 - 1. Grading and quality characteristics showing compliance with requirements for the Work.
 - 2. Certify that material meets requirements of the Project.
- C. Samples:
 - 1. If required, provide 40-pound samples of all imported trench bedding and backfill material sealed in airtight containers, tagged with source locations and suppliers of each proposed material.
 - 2. Provide materials from same source throughout work. Change of source requires approval of the Owner.

1.06 QUALITY ASSURANCE

- A. Conform all work to the appropriate portion(s) of the Caltrans Standard Specifications, Section 19.
- B. Percentage of compaction specified shall be the minimum acceptable. The percentage represents the ratio of the dry density of the compacted material to the maximum dry density of the material as determined by the procedure set forth in ASTM D 1557.
- C. Conform work to the requirements of the International Building Code.
 - 1. Section 1806A.11 – Pipe and Trenches.

1.07 PROJECT CONDITIONS

- A. Promptly notify the Owner of surface or subsurface conditions differing from those disclosed in the construction documents. First notify the Owner verbally to permit verification and extent of condition and then in writing. No claim for conditions differing from those anticipated in the Contract Documents will be allowed unless Contractor has notified the Owner in writing of differing conditions prior to contractor starting work on affected items.
- B. Protect open, trenches, and utility structure excavations with fences, covers and railings to maintain safe pedestrian and vehicular traffic passage.
- C. Stockpile on-site and imported backfill material temporarily in an orderly and safe manner.
- D. Provide dust and noise control in conformance with Division 1 General Requirements for Cleaning and Waste Management.

PART 2 - PRODUCTS

2.01 PIPE BEDDING AND INITIAL BACKFILL

Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft-AE Project No. 22-113

12/18/23

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- A. ASTM D 2321, Class IA, IB or II.
 - 1. Clean and free of clay, silt or organic matter.
- B. Permeable Material: Conform to Section 68-2.02F of Standard Specifications, Class 2 permeable.
- C. Class 2 Aggregate Base: Conform to Section 26 of Standard Specifications, ¾-inch maximum. Material shall also be non-expansive and predominantly granular soil or soil-rock mixture “(percent of passing #200: 50 maximum, 5 minimum)” with plasticity index of 15 or less.
- D. Sand: Conform to Section 19-3.02F of Standard Specifications.

2.02 WARNING TAPE

- A. See Section **33 10 00** – Water Utilities.

2.03 SUBSEQUENT BACKFILL

- A. Conform to on-site or imported structural backfill in Section 31 23 00 – Excavation and Fill.

2.04 CONTROLLED DENSITY FILL (CDF) (IN TRENCHES)

- A. Provide non-structural CDF, from bottom of trench to finish subgrade of subbase or base material, that can be excavated by hand and produce unconfined compressive 28-day strengths from 50-psi to a maximum of 150-psi. Provide aggregate no larger than 3/8-inch top size. The 3/8-inch aggregate shall not comprise more than 30% of the total aggregate content.
- B. Cement: Conform to the standards as set forth in ASTM C-150, Type II Cement.
- C. Fly Ash: Conform to the standards as set forth in ASTM C-618, for Class F pozzolan. Do not inhibit the entrainment of air with the fly ash.
- D. Air Entraining Agent: Conform to the standards as set forth in ASTM C-260.
- E. Aggregates need not meet the standards as set forth in ASTM C-33. Any aggregate, producing performances characteristics described herein will be accepted for consideration. The amount of material passing a #200 sieve shall not exceed 12% and no plastic fines shall be present.
- F. Provide CDF that is a mixture of cement, Class F pozzolan, aggregate, air entraining agent and water. CDF shall be batched by a ready mixed concrete plant and delivered to the job site by means of transit mixing trucks.
- G. The Contractor shall determine the actual mix proportions of the controlled density fill to meet job site conditions, minimum and maximum strengths, and unit weight. Entrained air content shall be a minimum of 4.0%. The actual entrained air content shall be established for each job with the materials and aggregates to be used to meet the placing and unit weight requirements. Entrained air content may be as high as 20% for fluidity requirements.

2.05 CONCRETE STRUCTURE BEDDING AND BACKFILL

- A. Precast Structures: Same materials to the same heights as specified for pipe bedding and backfill.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

B. Poured-in-Place Structures:

1. Bedding: In general, bedding is not required, pour bases against undisturbed native earth in cut areas and against engineered fill compacted to 90% relative compaction in embankment areas.
2. Side Backfill: On-site or imported structural fill meeting the requirements given in Section 31 23 00 – Excavation and Fill.

2.06 FILTER FABRIC

A. Filter Fabric:

1. Filter Fabric: Section 47-2.03C of Standard Specifications.
2. Mirafi 140N (Mirafi Inc., Charlotte, NC) (Tel. 800-438-1855) or equal.

PART 3 - EXECUTION

3.01 TRENCHING AND EXCAVATION

- A. Existing PCC or AC Areas: Cut PCC or AC to full depth at a minimum distance of 12-inches beyond the edge of the trench.
- B. Excavate by hand or machine. For gravity systems begin excavation at the outlet end and proceed upstream. Excavate sides of the trench parallel and equal distant from the centerline of the pipe. Hand trim excavation. Remove loose matter.
- C. Excavation Depth for Bedding: Minimum of 4-inches below bottom, except that bedding is not required for nominal pipe diameters of 2-inches or less.
- D. Excavation Width at Springline of Pipe:
 1. Up to a nominal pipe diameter of 24-inches: Minimum of twice the outside pipe diameter.
 2. Nominal pipe diameter of 30-inches through 36-inches: Minimum of the outside pipe diameter plus 2-feet.
 3. Nominal pipe diameter of 42-inches through 60-inches: Minimum of the outside pipe diameter plus 3-feet.
- E. Over-Excavations: Backfill trenches that have been excavated below bedding design subgrade, with approved bedding material.
- F. Comply with the Owner's limitations on the amount of trench that is opened or partially opened at any one time. Do not leave trenches open overnight without the approval of the Owner.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- G. Where forming is required, excavate only as much material as necessary to permit placing and removal of forms.
- H. Grade bottom of trench to provide uniform thickness of bedding material and to provide uniform bearing and support for pipe along entire length. Remove stones to avoid point bearing.

3.02 CONTROL OF WATER AND DEWATERING

- A. Be solely responsible for dewatering trenches and excavations and subsequent control of ground and surface water. Provide and maintain such pumps or other equipment as may be necessary to control ground water.
- B. Dewater during backfilling operation so that groundwater is maintained a least one foot below level of compaction effort.
- C. Reroute surface water runoff away from open trenches and excavations. Do not allow water to accumulate in trenches and excavations.
- D. Maintain dewatering system in place until dewatering is no longer required.

3.03 BRACING AND SHORING

- A. Conform to Federal OSHA requirements.
- B. Place and maintain such bracing and shoring as may be required to support the sides of the excavations for the proper protection of workmen; to facilitate the work; to prevent damage to the pipes and appurtenances being constructed; and to prevent damage to adjacent structures or facilities. Remove all bracing and shoring upon completion of the work.
- C. Be solely responsible for all bracing and shoring and, if requested by the Owner, submit details and calculations to the Owner. The Owner may forward the submittal to the Consulting Engineer and/or the Division of Industrial Safety for their review. The Contractor's submittal shall include the basic design, assumed soils conditions and estimation of forces to be resisted, together with plans and specifications of the materials and methods to be used, and shall be prepared by a civil engineer or structural engineer. No excavations in trench section or around structures shall precede a response to the submittal by the Owner.
- D. Be solely responsible for installing and extracting the sheathing in a manner which will not disturb the line, grade, or backfill compaction or operation of the utility being installed or adjacent utilities and facilities.

3.04 PIPE BEDDING

- A. Accurately shape bedding material to the line and grade called for on the Plans. Carefully place and compact bedding material to the elevation of the bottom of the pipe in layers not exceeding 8-inches in loose thickness. Compact bedding material at optimum water content to 95% relative compaction unless specified otherwise on the. Compact by pneumatic tampers or other mechanical means. Jetting or ponding of bedding material will not be permitted.

3.05 WARNING TAPE

- A. Install in accordance with Section **33 10 00** – Water Utilities.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

3.06 BACKFILLING

- A. Bring initial backfill up simultaneously on both sides of the pipe, so as to prevent any displacement of the pipe from its true alignment. Carefully place and compact initial backfill material to an elevation of 12-inches above the top of the pipe in layers not exceeding 8-inches in loose thickness. Compact bedding material at optimum water content to 90% relative compaction unless specified otherwise on the. Compact by pneumatic tampers or other mechanical means. Jetting or ponding of initial backfill material will not be permitted.
- B. Bring subsequent backfill to subgrade or finish grade as indicated. Carefully place and compact subsequent backfill material to the proper elevation in layers not exceeding 8-inches in loose thickness. Compact bedding material at optimum water content to 90% relative compaction, unless specified otherwise on the Plans. Compact by pneumatic tampers or other mechanical means. Jetting or ponding of subsequent backfill material will not be permitted.
- C. Do not use compaction equipment or methods that produce horizontal or vertical earth pressures that may cause excessive pipe displacement or damage the pipe.

3.07 CLEANUP

- A. Upon completion of utility earthwork all lines, manholes catch basins, inlets, water meter boxes and other structures shall be thoroughly cleaned of dirt, rubbish, debris and obstructions of any kind to the satisfaction of the Owner.
- B. See Section 01 74 00 – Refer to Division 1 General Requirements for Cleaning and Waste Management for further cleanup requirements.

END OF SECTION

DIVISION 32

11-09-21

SECTION 32 05 23
CEMENT AND CONCRETE FOR EXTERIOR IMPROVEMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Subbase for concrete pavements.
 - 2. Curbs, gutters, and combination curbs and gutters wheel stops.
 - 3. Pedestrian Pavement: Walks, grade slabs, pedestrian crossings, wheelchair curb ramps and steps.
 - 4. Vehicular Pavement: Service courts, driveways, parking lots, and loading docks.
 - 5. Equipment Pads: Oxygen storage, transformers, propane tanks, and generator pads
- B. Field Testing: Section 01 45 29, TESTING LABORATORY SERVICES.
- C. Step Nosings and Railings: Section 05 50 00, METAL FABRICATIONS.
- D. Subgrade Preparation and Subbase Compaction: Section 31 20 00, EARTHWORK.

1.2 APPLICABLE PUBLICATIONS

- A. Comply with references to extent specified in this section.
- B. American Association of State Highway and Transportation Officials (AASHTO):
 - 1. M147-65-UL-04 - Materials for Aggregate and Soil-Aggregate Subbase, Base and Surface Courses.
 - 2. M233-86 - Boiled Linseed Oil Mixture for Treatment of Portland Cement Concrete.
- C. American Concrete Institute (ACI):
 - 1. 305R-10 - Guide to Hot Weather Concreting.
 - 2. 306R-10 - Guide to Cold Weather Concreting.
- D. American National Standards Institute (ANSI):
 - 1. B101.3 - Wet DOCF of Common Hard Surface Floor Materials (Including Action and Limit Thresholds for the Suitable Assessment of the Measured Values).
- E. ASTM International (ASTM):

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Medical Center
Fargo, North Dakota 58102
EHRM Infrastructure Upgrades - Fargo ND
Bancroft Architects + Engineers

11-09-21

1. A615/A615M-16 - Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.
2. A996/A996M-15 - Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement.
3. A1064/A1064M-16 - Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
4. C33/C33M-16 - Concrete Aggregates.
5. C94/C94M-16 - Ready Mixed Concrete.
6. C143/C143M-15a - Slump of Hydraulic Cement Concrete.
7. C150/C150M-16 - Portland Cement.
8. C171-16 - Sheet Materials for Curing Concrete.
9. C260/C260M-10a - Air Entraining Admixtures for Concrete.
10. C309-11 - Liquid Membrane Forming Compounds for Curing Concrete.
11. C494/C494M-15a - Chemical Admixtures for Concrete.
12. C618-15 - Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
13. C979/C979M-16 - Pigments for Integrally Colored Concrete.
14. C989/C989M-14 - Slag Cement for Use in Concrete and Mortars.
15. C1240-15 - Silica Fume Used in Cementitious Mixtures.
16. D1751-04(2013)e1 - Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
17. D5893/D5893M-10 - Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements.
18. D6690-15 - Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements.

1.3 PREINSTALLATION MEETINGS

- A. Conduct preinstallation meeting at project site minimum 30 days before beginning Work of this section.
 1. Required Participants:
 - a. Contracting Officer's Representative.
 - b. Inspection and Testing Agency.
 - c. Contractor.
 - d. Installer.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Medical Center
Fargo, North Dakota 58102
EHRM Infrastructure Upgrades - Fargo ND
Bancroft Architects + Engineers

11-09-21

- e. Other installers responsible for adjacent and intersecting work, including excavation, plantings, traffic markings, and utilities.
- 2. Meeting Agenda: Distribute agenda to participants minimum 3 days before meeting.
 - a. Installation schedule.
 - b. Installation sequence.
 - c. Preparatory work.
 - d. Protection before, during, and after installation.
 - e. Installation.
 - f. Terminations.
 - g. Transitions and connections to other work.
 - h. Inspecting and testing.
 - i. Other items affecting successful completion.
- 3. Document and distribute meeting minutes to participants to record decisions affecting installation.

1.4 SUBMITTALS

- A. Submittal Procedures: Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Submittal Drawings:
 - 1. Show size, configuration, and fabrication and installation details.
 - 2. Show reinforcing.
 - 3. Include jointing plan for concrete pavements, curbs and gutters.
- C. Manufacturer's Literature and Data:
 - 1. Description of each product.
 - 2. Installation instructions.
- D. Samples:
 - 1. Exposed Aggregate Concrete Panel: 0.4 sq. m by 50 mm (4 sq. ft. by 2 inches) thick, 2 required, each color and finish.
 - 2. Colored Concrete Panel: As specified in Section 09 06 00, SCHEDULE FOR FINISHES, with mix data.
- E. Test reports: Certify products comply with specifications.
 - 1. Concrete materials.
 - 2. Select subbase materials.
 - 3. Field test reports.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Medical Center
Fargo, North Dakota 58102
EHRM Infrastructure Upgrades - Fargo ND
Bancroft Architects + Engineers

11-09-21

- F. Certificates: Certify products comply with specifications.
 - 1. Expansion joint filler.
 - 2. Reinforcement.
 - 3. Curing materials.
 - 4. Concrete protective coating.
- G. Qualifications: Substantiate qualifications comply with specifications.
 - 1. Installer with project experience list.
 - 2. Land surveyor.
- H. Concrete mix design.
- I. Select subbase job-mix design.
- J. Proposed hot and cold weather concreting methods.
- K. Land surveyor's construction staking notes, before placing concrete.
 - 1. Identify discrepancies between field conditions and Drawings.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Regularly installs specified products.
 - 2. Installed specified products with satisfactory service on five similar installations.
 - a. Project Experience List: Provide contact names and addresses for completed projects.
- B. Land Surveyor: Professional land surveyor or engineer registered to provide land surveys in jurisdiction where project is located.
- C. Preconstruction Testing:
 - 1. Engage independent testing laboratory to perform tests and submit reports.
 - a. Deliver samples to laboratory in number and quantity required for testing.
 - 2. Concrete mix design.
 - 3. Select subbase job-mix design. Report the following:
 - a. Material sources.
 - b. Gradation.
 - c. Plasticity index.
 - d. Liquid limit.
 - e. Laboratory compaction curves indicating maximum density at optimum moisture content.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Medical Center
Fargo, North Dakota 58102
EHRM Infrastructure Upgrades - Fargo ND
Bancroft Architects + Engineers

11-09-21

1.6 DELIVERY

- A. Deliver steel reinforcement to prevent damage.
- B. Before installation, return or dispose of distorted or damaged steel reinforcement.
- C. Bulk Products: Deliver bulk products away from buildings, utilities, pavement, and existing turf and planted areas. Maintain dry bulk product storage away from contaminants.

1.7 STORAGE AND HANDLING

- A. Store products indoors in dry, weathertight facility.
- B. Protect products from damage during handling and construction operations.

1.8 FIELD CONDITIONS

- A. Hot Weather Concreting Procedures: ACI 305R.
- B. Cold Weather Concreting Procedures: ACI 306R.
 - 1. Use non-corrosive, non-chloride accelerator admixture.
 - 2. Do not use calcium chloride, thiocyanates or admixtures containing more than 0.05 percent chloride ions.

1.9 WARRANTY

- A. Construction Warranty: FAR clause 52.246-21, "Warranty of Construction."

PART 2 - PRODUCTS

2.1 CONCRETE MATERIALS

- A. Portland Cement: ASTM C150/C150M, Type I or II.
- B. Pozzolans:
 - 1. Fly Ash: ASTM C618, Class C or F including supplementary optional physical requirements.
 - 2. Slag: ASTM C989/C989M; Grade 80, Grade 100 or Grade 120. Contractor to refer to Geotech Report for specific material.
 - 3. Silica Fume: ASTM C1240. Contractor to refer to Geotech Report for specific material.
- C. Coarse Aggregate: ASTM C33/C33M; size to suit application.
- D. Fine Aggregate: ASTM C33/C33M.
- E. Mixing Water: Fresh, clean, and potable.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Medical Center
Fargo, North Dakota 58102
EHRM Infrastructure Upgrades - Fargo ND
Bancroft Architects + Engineers

11-09-21

- F. Air-Entraining Admixture: ASTM C260/C260M.
- G. Chemical Admixtures: ASTM C494/C494M.
- H. Reinforcing Steel: ASTM A615/A615M or ASTM A996/A996M deformed.
Contractor to refer to Geotech Report for specific material.
- I. Welded Wire Fabric: ASTM A1064/A1064M, plain; Grade 385 (56); sized as indicated. Contractor to refer to Geotech Report for specific material.
- J. Expansion Joint Filler: ASTM D1751. Contractor to refer to Geotech Report for specific material.
- K. Sheet Materials for Curing Concrete: ASTM C171. Contractor to refer to Geotech Report for specific material.
- L. Color Pigment: ASTM C979/C979M, colored and white powder pigments.

2.2 SELECT SUBBASE

- A. Subbase: AASHTO M147; Grade A. Contractor to refer to Geotech Report for specific material.
1. Select granular material composed of sand, sand-gravel, crushed stone, crushed or granulated slag, with or without soil binder, or combinations of these materials.

SUBBASE GRADING REQUIREMENTS							
Sieve Size		Percentage Passing by Mass					
		Grades					
(mm)	(in)	A	B	C	D	E	F
50	2	100	100				
25	1		75-95	100	100	100	100
9.5	3/8	30-65	40-75	50-85	60-100		
4.47	No. 4	25-55	30-60	35-65	50-85	55-100	70-100
2.00	No. 10	15-40	20-45	25-50	40-70	40-100	55-100
0.425	No. 40	8-20	15-30	15-30	25-45	20-50	30-70
0.075	No. 200	2-8	5-20	5-15	5-20	6-20	8-25

- B. Other Acceptable Gradations: Materials within three to five percent, plus or minus, of specified gradation, or as recommended by the geotechnical engineer and approved by the Contracting Officer's Representative.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Medical Center
Fargo, North Dakota 58102
EHRM Infrastructure Upgrades - Fargo ND
Bancroft Architects + Engineers

11-09-21

2.3 FORMS

- A. Forms: Wood, plywood, metal, or other materials, approved by Contracting Officer's Representative, of grade or type suitable to obtain type of finish specified.
 - 1. Plywood: Exterior grade, free of defects and patches on contact surface.
 - 2. Lumber: Sound, grade-marked, S4S stress graded softwood, minimum 50 mm (2 inches) thick, free from warp, twist, loose knots, splits, or other defects.
 - 3. Form Coating: As recommended by Architect/Engineer.
- B. Provide forms suitable in cross-section, depth, and strength to resist springing during depositing and consolidating concrete.
 - 1. Do not use forms varying from straight line more than 3 mm in 3000 mm (1/8 inch in 10 feet), horizontally and vertically.
- C. Provide flexible or curved forms for forming radii.

2.4 CONCRETE CURING MATERIALS

- A. Concrete curing materials, conform to one of the following:
 - 1. Burlap: Minimum 233 g/sq. m (7 ounces/sq. yd.) dry.
 - 2. Sheet Materials for Curing Concrete: ASTM C171.
 - 3. Curing Compound: ASTM C309, Type 1 clear ; liquid membrane forming type, without paraffin or petroleum.

2.5 CONCRETE MIXES

- A. Design concrete mixes according to ASTM C94/C94M, Option C.
- B. Concrete Type: Air-entrained. See Table I.

TABLE I - CONCRETE TYPES					
Concrete Type	Minimum 28 Day Compressive Strength f'c MPa (psi)	Non-Air-Entrained		Air-Entrained	
		Min. Cement kg/cu. m (lbs./cu. yd.)	Max. Water Cement Ratio	Min. Cement kg/cu. m (lbs./cu. yd.)	Max. Water Cement Ratio
A	35 (5000) 1,3	375 (630)	0.45	385 (650)	0.40
B	30 (4000) 1,3	325 (550)	0.55	340 (570)	0.50
C	25 (3000) 1,3	280 (470)	0.65	290 (490)	0.55

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Medical Center
Fargo, North Dakota 58102
EHRM Infrastructure Upgrades - Fargo ND
Bancroft Architects + Engineers

11-09-21

D	25 (3000)1,2	300 (500)	*	310 (520)	*
Footnotes: 1. If trial mixes are used, achieve compressive strength 8.3 MPa (1,200 psi) in excess of f'c. For concrete strengths greater than 35 MPa (5,000 psi), achieve compressive strength 9.7 MPa (1,400 psi) in excess of f'c. 2. For Concrete Exposed to High Sulfate Content Soils: Maximum water cement ratio is 0.44. 3. Laboratory Determined according to ACI 211.1 for normal weight concrete.					

C. Maximum Slump: ASTM C143/C143M. See Table II.

TABLE II - MAXIMUM SLUMP	
APPLICATION	MAXIMUM SLUMP
Curb & Gutter	75 mm (3 inches)
Pedestrian Pavement	75 mm (3 inches)
Vehicular Pavement	50 mm (2 inches) Machine Finished 100 mm (4 inches) Hand Finished
Equipment Pad	75 to 100 mm (3 to 4 inches)

2.6 ACCESSORIES

- A. Equipment and Tools: Obtain Contracting Officer's Representative's, approval of equipment and tools needed for handling materials and performing work before work begins.
- B. Maintain equipment and tools in satisfactory working condition.
- C. Sealants:
 - 1. Concrete Paving Expansion Joints: ASTM D5893/D5893M, Type SL, single component, self-leveling, silicone joint sealant.
 - 2. Concrete Paving Joints: ASTM D6690, Type IV, hot-applied, single component joint sealant.
- D. Concrete Protective Coating: AASHTO M233 linseed oil mixture.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Examine and verify substrate suitability for product installation.
- B. Protect existing construction and completed work from damage.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Medical Center
Fargo, North Dakota 58102
EHRM Infrastructure Upgrades - Fargo ND
Bancroft Architects + Engineers

11-09-21

- C. Prepare, construct, and finish subgrade. See Section 31 20 00, EARTHWORK.
- D. Maintain subgrade in smooth, compacted condition, in conformance with the required section and established grade until the succeeding operation has been accomplished.

3.2 SELECT SUBBASE

- A. Placing:
 - 1. Place subbase material on prepared subgrade in uniform layer to required contour and grades, and to maximum 200 mm (8 inches) loose depth.
 - 2. When required compacted thickness exceeds 150 mm (6 inches), place subbase material in equal thickness layers.
 - 3. When subbase elevation is 13 mm (1/2 inch) or more below required grade, excavate subbase minimum 75 mm (3 inches) deep. Place and compact subbase to required grade.
- B. Compaction:
 - 1. Perform compaction with approved hand or mechanical equipment well suited to the material being compacted.
 - 2. Maintain subbase at optimum moisture content for compaction.
 - 3. Compact each subbase layer to minimum 95 percent or 100 percent of maximum density as specified in Section 31 20 00, EARTHWORK.
- C. Subbase Tolerances:
 - 1. Variation from Indicated Grade: Maximum 9 mm (3/8 inch).
 - 2. Variation from Indicated Thickness: Maximum 13 mm (1/2 inch).
- D. Protection:
 - 1. Protect subbase from damage until concrete is placed.
 - 2. Reconstruct damaged subbase before placing concrete.

3.3 SETTING FORMS

- A. Form Substrate:
 - 1. Compact form substrate to uniformly support forms along entire length.
 - 2. Correct substrate imperfections and variations by cutting, filling, and compacting.
- B. Form Setting:

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Medical Center
Fargo, North Dakota 58102
EHRM Infrastructure Upgrades - Fargo ND
Bancroft Architects + Engineers

11-09-21

1. Set forms to indicated line and grade with tight joints. Rigidly brace forms preventing movement.
2. Remove forms when removal will not damage concrete and when required for finishing.
3. Clean and oil forms before each use.
4. Correct forms, when required, immediately before placing concrete.
- C. Land Surveyor: Establish control, alignment, and grade for forms and slip forming machine operations.
 1. Notify Contracting Officer's Representative immediately when discrepancies exist between field conditions and drawings.
 2. Correct discrepancies greater than 25 mm (1 inch) before placing concrete.
- D. Form Tolerances:
 1. Variation from Indicated Line: Maximum 6 mm (1/4 inch).
 2. Variation from Indicated Grade: Maximum 3 mm in 3000 mm (1/8 inch in 10 feet).

3.4 PLACING REINFORCEMENT

- A. Keep reinforcement clean from contamination preventing concrete bond.
- B. Install reinforcement shown on drawings.
- C. Support and securely tie reinforcing steel to prevent displacement during concrete placement.
- D. Obtain Contracting Officer's Representative's reinforcement placement approval before placing concrete.

3.5 JOINTS - GENERAL

- A. Place joints, where shown on approved submittal Drawings.
 1. Conform to details shown.
 2. Install joints perpendicular to finished concrete surface.
- B. Make joints straight and continuous from edge to edge of pavement.

3.6 CONSTRUCTION JOINTS

- A. Locate longitudinal and transverse construction joints between slabs of vehicular pavement as shown on approved submittal Drawings.
- B. Place transverse construction joints of type shown, where indicated, and whenever concrete placement is suspended for more than 30 minutes.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Medical Center
Fargo, North Dakota 58102
EHRM Infrastructure Upgrades - Fargo ND
Bancroft Architects + Engineers

11-09-21

- C. Provide butt-type joint with dowels in curb and gutter at planned joint locations.
- D. Provide keyed joints with tie bars when joint occurs in middle third of planned curb and gutter joint interval.

3.7 CONTRACTION JOINTS

- A. Tool or cut joints to width, depth, and radius edge shown on drawings using grooving tool, jointer, or saw.
- B. Construct joints in curbs and gutters by inserting 3 mm (1/8 inch) steel plates conforming to curb and gutter cross sections.
 - 1. Keep plates in place until concrete can hold its shape.
- C. Finish joint edges with edging tool.
- D. Score pedestrian pavement with grooving tool or jointer.

3.8 EXPANSION JOINTS

- A. Form expansion joints with expansion joint filler of thickness shown on drawings.
 - 1. Locate joints around perimeter of structures and features abutting site work concrete.
 - 2. Create complete, uniform separation between structure and site work concrete.
- B. Extend expansion joint material full depth of concrete with top edge of joint filler below finished concrete surface where sealant is indicated on Drawings.
- C. Cut and shape material matching cross section.
- D. Anchor with approved devices to prevent displacing during placing and finishing operations.
- E. Round joint edges with edging tool.

3.9 PLACING CONCRETE - GENERAL

- A. Preparation before Placing Concrete:
 - 1. Obtain Contracting Officer's Representative approval.
 - 2. Remove debris and other foreign material.
 - 3. Uniformly moisten substrate, without standing water.
- B. Convey concrete from mixer to final location without segregation or loss of ingredients. Deposit concrete to minimize handling.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Medical Center
Fargo, North Dakota 58102
EHRM Infrastructure Upgrades - Fargo ND
Bancroft Architects + Engineers

11-09-21

- C. During placement, consolidate concrete by spading or vibrating to minimize voids, honeycomb, and rock pockets.
 - 1. Vibrate concrete against forms and along joints.
 - 2. Avoid excess vibration and handling causing segregation.
- D. Place concrete continuously between joints without bulkheads.
- E. Install construction joint in concrete placement suspended for more than 30 minutes.
- F. Replace concrete with cracks, chips, bird baths, and other defects to nearest joints, approved by Contracting Officer's Representative.

3.10 PLACING CONCRETE FOR CURB AND GUTTER, PEDESTRIAN PAVEMENT, AND EQUIPMENT PADS

- A. Place concrete in one layer conforming to cross section shown on Drawings after consolidating and finishing.
- B. Deposit concrete near joints without disturbing joints. Do not place concrete directly onto joint assemblies.
- C. Strike concrete surface to proper section ready for consolidation.
- D. Consolidate concrete by tamping and spading or with approved mechanical finishing equipment.
- E. Finish concrete surface with wood or metal float.
- F. Construct concrete pads and pavements with sufficient slope to drain, preventing standing water.

3.11 PLACING CONCRETE FOR VEHICULAR PAVEMENT

- A. Deposit concrete as close as possible to its final position.
- B. Place concrete continuously between construction joints without cold joints.
- C. Strike and consolidate concrete with finishing machine, vibrating screed, or by hand-finishing.
- D. Finish concrete surface to elevation and crown shown on drawings.
- E. Deposit concrete near joints without disturbing joints. Do not place concrete directly onto joint assemblies.
- F. Obtain Contracting Officer's Representative's approval before placing adjacent lanes.
- G. Curb-Forming Machines: Curb-forming machines for constructing integral curbs, curbs and gutters will be approved based on trial use on the

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

11-09-21

project. When equipment produces unsatisfactory results, discontinue use of the equipment at any time during construction and accomplish work by hand method construction. Remove unsatisfactory work and reconstruct full length between regularly scheduled joints. Dispose of removed portions off the project site.

3.12 FORM REMOVAL

- A. Keep forms in place minimum 12 hours after concrete placement. Remove forms without damaging concrete.
- B. Do not use bars or heavy tools against concrete to remove forms. Repair damage concrete found after form removal.

3.13 CONCRETE FINISHING - GENERAL

- A. Follow operation sequence below, unless otherwise indicated on Drawings:
 - 1. Consolidating, floating, striking, troweling, texturing, and joint edging.
- B. Use edging tool with 6 mm (1/4 inch) radius, unless otherwise shown on Drawings.
- C. Keep finishing equipment and tools clean and suitable for use.

3.14 CONCRETE FINISHING - PEDESTRIAN PAVEMENT

- A. Walks, Grade Slabs, Wheelchair Curb Ramps Terraces:
 - 1. Finish concrete surfaces with metal float, troweled smooth, and finished with a broom moistened with clear water.
 - 2. Finish slab edges and formed transverse joints with edger.
 - 3. Broom surfaces transverse to traffic direction.
 - a. Use brooming to eliminate flat surface produced by edger.
 - b. Produce uniform corrugations, maximum 1.5 mm (1/16 inch) deep profile.
 - 4. Provide surface uniform in color and free of surface blemishes, form marks, and tool marks.
 - 5. Paving Tolerances:
 - a. Variation from Indicated Plane: Maximum 5 mm in 3000 mm (3/16 inch in 10 feet).
 - b. Variation from Indicated Thickness: Maximum 6 mm (1/4 inch).

Fargo VA Medical Center
Fargo, North Dakota 58102
EHRM Infrastructure Upgrades - Fargo ND
Bancroft Architects + Engineers

11-09-21

6. Replace paving within joint boundary when paving exceeds specified tolerances.
- B. Step Treads, Risers and Sidewalls: Finish as specified for pedestrian pavement, except as follows:
 1. Remove riser forms sequentially, starting with top riser.
 2. Rub riser face with wood or concrete rubbing block and water. Remove blemishes, form marks, and tool marks. Use outside edger to round nosing; use inside edger to finish bottom of riser.
 3. Apply uniform brush finish to treads, risers, and sidewall.
 - a. Apply stiff brush finish to treads to provide slip resistant surface complying with ANSI B101.3.
 4. Step Tolerance:
 - a. Variation from Indicated Plane: Maximum 5 mm in 3000 mm (3/16 inch in 10 feet).

3.15 CONCRETE FINISHING - VEHICULAR PAVEMENT

- A. Align finish surfaces where new and existing pavements abut.
- B. Longitudinally float pavement surface to profile and grade indicated on drawings.
- C. Straighten surface removing irregularities and maintaining specified tolerances while concrete is plastic.
- D. Finish pavement edges and joints with edging tool.
- E. Broom finish concrete surface after bleed water dissipates and before concrete hardens.
 1. Broom surface transverse to traffic direction.
 - a. Use brooming to eliminate flat surface produced by edger.
 - b. Produce uniform corrugations, maximum 3 mm (1/8 inch) deep profile.
- F. Pavement Tolerances:
 1. Variation from Indicated Plane: Maximum 6 mm in 3000 mm (1/4 inch in 10 feet) tested parallel and perpendicular to traffic direction at maximum 1500 mm (5 feet) intervals.
 2. Variation from Indicated Thickness: Maximum 6 mm (1/4 inch).
- G. Replace paving within joint boundary when paving exceeds specified tolerances.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

11-09-21

3.16 CONCRETE FINISHING - CURBS AND GUTTERS

- A. Round edges of gutter and top of curb with edging tool.
- B. Gutter and Curb Top:
 - 1. Float surfaces and finish with smooth wood or metal float until true to grade and section and uniform color.
 - 2. Finish surfaces, while still plastic, longitudinally with bristle brush.
- C. Curb Face:
 - 1. Remove curb form and immediately rub curb face with wood or concrete rubbing block removing blemishes, form marks, and tool marks and providing uniform color.
 - 2. Brush curb face, while still plastic, matching gutter and curb top.
- D. Curb and Gutter Tolerances: Except at grade changes or curves.
 - 1. Variation from Indicated Plane and Grade:
 - a. Gutter: Maximum 3 mm in 3000 mm (1/8 inch in 10 feet).
 - b. Curb Top and Face: Maximum 6 mm in 3000 mm (1/4 inch in 10 feet).
- E. Replace curbs and gutters within joint boundary when curbs and gutters exceed specified tolerances.
- F. Correct depressions causing standing water.

3.17 CONCRETE FINISHING - EQUIPMENT PADS

- A. Strike pad surface to elevation shown on Drawings.
- B. Provide smooth, dense float finish, free from depressions or irregularities.
- C. Finish pad edges with edger.
- D. After removing forms, rub pad edge faces with wood or concrete rubbing block, removing blemishes, form marks, and tool marks and providing uniform color.
- E. Pad Tolerances:
 - 1. Variation from Indicated Plane: Maximum 3 mm in 3000 mm (1/8 inch in 10 feet).
 - 2. Variation from Indicated Elevation: Maximum 6 mm (1/4 inch).
 - 3. Variation from Indicated Thickness: Maximum 6 mm (1/4 inch).
- F. Replace pads when pads exceed specified tolerances.

11-09-21

3.18 SPECIAL FINISHES

A. Exposed Aggregate Finish:

1. Prepare concrete base 10 to 13 mm (3/8 to 1/2 inch) lower than the finish grade.
2. Scatter aggregate over concrete base surface and embed by use of hand float, straight edge or darby.
3. Apply concrete mix and mark off surface as indicated on Drawings with surface joints at least 10 mm (3/8 inch) deep. Level off finish to a true surface and compact with wood float, working as little as possible so that coarse material will remain at the top. Before finish has set, treat top surface with cement retarding material. When body of concrete finish has set, remove retarded surface film by wire brushes and fine water spray to remove mortar from top of colored aggregate. Continue washing and brushing until flush water runs clear and no noticeable cement film left on the aggregate.

3.19 CONCRETE CURING

A. Concrete Protection:

1. Protect unhardened concrete from rain and flowing water.
2. Provide sufficient curing and protection materials available and ready for use before concrete placement begins.
3. Protect concrete to prevent pavement cracking from ambient temperature changes during curing period.
 - a. Replace pavement damaged by curing method allowing concrete cracking.
 - b. Employ another curing method as directed by Contracting Officer's Representative.

B. Cure concrete for minimum 7 days by one of the following methods appropriate to weather conditions preventing moisture loss and rapid temperature change:

1. Burlap Mat: Provide minimum two layers kept saturated with water during curing period. Overlap Mats at least 150 mm (6 inches).
2. Sheet Materials:
 - a. Wet exposed concrete surface with fine water spray and cover with sheet materials.
 - b. Overlap sheets minimum 300 mm (12 inches).

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Medical Center
Fargo, North Dakota 58102
EHRM Infrastructure Upgrades - Fargo ND
Bancroft Architects + Engineers

11-09-21

- c. Securely anchor sheet materials preventing displacement.
- 3. Curing Compound:
 - a. Protect joints indicated to receive sealants preventing contamination from curing compound.
 - b. Insert moistened paper or fiber rope into joint or cover joint with waterproof paper.
 - c. Apply curing compound before concrete dries.
 - d. Apply curing compound in two coats at right angles to each other.
 - e. Application Rate: Maximum 5 sq. m/L (200 sq. ft./gallon), both coats.
 - f. Immediately reapply curing compound to surfaces damaged during curing period.

3.20 CONCRETE PROTECTIVE COATING

- A. Apply protective coating of linseed oil mixture to exposed-to-view concrete surfaces, drainage structures, and features that project through, into, or against concrete exterior improvements to protect the concrete against deicing materials.
- B. Complete backfilling and curing operation before applying protective coating.
- C. Dry and thoroughly clean concrete before each application.
- D. Apply two coats, with maximum coverage of 11 sq. m/L (50 sq. yds./gal.); first coat, and maximum 16 sq. m/L (70 sq. yds./gal.); second coat, except apply commercially prepared mixture according to manufacturer's instructions.
- E. Protect coated surfaces from vehicular and pedestrian traffic until dry.
- F. Do not heat protective coating, and do not expose protective coating to open flame, sparks, or fire adjacent to open containers or applicators. Do not apply material at temperatures lower than 10 degrees C (50 degrees F).

3.21 FIELD QUALITY CONTROL

- A. Field Tests: Performed by testing laboratory specified in Section 01 45 29, TESTING LABORATORY SERVICES.

Contract No. 36C26319D0044
Station Project No. 437-21-210
Bancroft-AE Project No. 22-113

01/16/2024

Fargo VA Medical Center
Fargo, North Dakota 58102
EHRM Infrastructure Upgrades - Fargo ND
Bancroft Architects + Engineers

11-09-21

1. Compaction.
 - a. Pavement subgrade.
 - b. Curb, gutter, and sidewalk.
2. Concrete:
 - a. Delivery samples.
 - b. Field samples.
3. Slip Resistance: Steps and pedestrian paving.

3.22 CLEANING

- A. After completing curing:
 1. Remove burlap and sheet curing materials.
 2. Sweep concrete clean, removing foreign matter from the joints.
 3. Seal joints as specified.

3.23 PROTECTION

- A. Protect exterior improvements from traffic and construction operations.
 1. Prohibit traffic on paving for minimum seven days after placement, or longer as directed by Contracting Officer's Representative.
- B. Remove protective materials immediately before acceptance.
- C. Repair damage.
 1. Replace concrete containing excessive cracking, fractures, spalling, and other defects within joint boundary, when directed by Contracting Officer's Representative, and at no additional cost to the Government.

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Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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SECTION 32 13 00
RIGID PAVING

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Furnishing, placing, spreading, compacting and shaping portland cement concrete pavement with undoweled transverse weakened plane joints, for vehicular traffic.
- B. Form construction and use in placing portland cement concrete pavement.
- C. Joints for portland cement concrete pavement.
- D. Finishing portland cement concrete pavement.
- E. Curing and protecting portland cement concrete pavement.

1.02 RELATED DOCUMENTS

- A. AASHTO Standard Specifications
 - 1. T 53: Softening Point of Bitumen (Ring-and-Ball Apparatus).
- B. ASTM Standards
 - 1. A 615: Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
 - 2. A 775: Epoxy Coated Reinforcing Steel Bars.
 - 3. A 934: Epoxy-Coated Prefabricated Steel Reinforcing Bars.
 - 4. C 881: Epoxy-Resin-Base Bonding Systems for Concrete.
 - 5. D 2628: Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements.
 - 6. D 2835: Lubricant for Installation of Preformed Compression Seals in Concrete Pavements.
 - 7. D 3405: Joint Sealants , Hot Poured , for Concrete and Asphalt Pavements.
 - 8. D 3963: Fabrication and Jobsite Handling of Epoxy-Coated Reinforcing Steel.
- C. Standard Specifications:
 - 1. Section 40, Portland Cement Concrete Pavement.
 - 2. Section 52, Reinforcement.
 - 3. Section 90, Portland Cement Concrete.
 - 4. Section 95, Epoxy.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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D. Standard Plans:

1. Plan A35A: Portland Cement Concrete Pavement (Undoweled Transverse Joints).
2. Plan A35C: Portland Cement Concrete Pavement Joint and End Anchor Details.

1.03 DEFINITIONS

- A. AASHTO: American Association of State Highway and Transportation Officials.
- B. ASTM: American Society for Testing and Materials.

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.
 1. Manufacturer must be certified according to the National Ready Mix Concrete Plant Certification Program.
- B. Installer Qualification: An experienced installer who has completed pavement work similar in material, design and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- C. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant and each aggregate from one source.

1.05 SUBMITTALS

- A. Follow submittal procedures outlined in Section 01 33 00 – Submittal Procedures.
- B. Design Mixes: For each concrete pavement mix. Include alternate mix designs when characteristics of materials, project conditions, weather, test results or other circumstances warrant adjustments.
- C. Material Certificates: Signed by manufacturers certifying that each of the following materials complies with requirements.
 1. Cementitious materials and aggregates.
 2. Steel reinforcement and reinforcement accessories.
 3. Admixtures.
 4. Curing compound.
 5. Applied finish material.
 6. Bonding agent or adhesive.
 7. Joint filler.
 8. Joint Sealant.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- 9. Tie Bars.
- 10. Epoxy.
- 11. Backer Rods.

PART 2 - PRODUCTS

2.01 PORTLAND CEMENT CONCRETE

- A. General: Conform to Standard Specifications, Section 90. Use Class 2 Concrete.

2.02 TIE BARS

- A. Deformed reinforcing steel bars conforming to the requirements of ASTM Designation A 615/A (615M), Grade 40 or 60 (Grade 300 or 420).
- B. Epoxy-coat in conformance with the provisions in Section 52-1.02B of Standard Specifications, except that references made to ASTM Designation D 3963/D 3963M shall be deemed to mean ASTM Designation A 934/A 934M or A 775/775M.
- C. Do not bend tie bars.

2.03 EPOXY

- A. Bond tie bars to existing concrete with epoxy resin conforming to Section 95-2.03, "Epoxy Resin Adhesive for Bonding New Concrete to Old Concrete," of the Standard Specifications.

2.04 SILICONE JOINT SEALANT

- A. Furnish low modulus silicone joint sealant in a one-part silicone formulation. Do not use acid cure sealants. Compound to be compatible with the surface to which it is applied and conform to the following requirements:

Specification	Test Method	Requirement
Tensile stress, 150% elongation, 7-day cure at 25°± 1°C and 45% to 55% R.H. ^e	ASTM D 412 (Die C)	310 kPa max.
Flow at 25° ± 1°C	ASTM C 639 ^a	Shall not flow from channel
Extrusion Rate at 25° ± 1°C	ASTM C 603 ^b	75-250 g/min.
Specific Gravity	ASTM D 792 Method A	1.01 to 1.51
Durometer Hardness, at -18°C, Shore A, cured 7 days at 25° ± 1°C	ASTM C 661	10 to 25
Ozone and Ultraviolet Resistance, after 5000 hours	ASTM C 793	No chalking, cracking or bond loss

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

Tack free at 25° ± 1°C and 45% to 55% R.H. ^e	ASTM C 679	Less than 75 minutes
Elongation, 7 day cure at 25° ± 1°C and 45% to 55% R.H. ^e	ASTM D 412 (Die C)	500 percent min.
Set to Touch, at 25° ± 1°C and 45% to 55% R.H. ^e	ASTM D 1640	Less than 75 minutes
Shelf Life, from date of shipment	—	6 months min.
Bond, to concrete mortar-concrete briquets, air cured 7 days at 25° ± 1°C	AASHTO T 132 ^c	345 kPa min.
Movement Capability and Adhesion, 100% extension at -18°C after, air cured 7 days at 25° ± 1°C, and followed by 7 days in water at 25° ± 1°C	ASTM C 719 ^d	No adhesive or cohesive failure after 5 cycles

Notes:

ASTM Designation: C 639 Modified (15 percent slope channel A).

ASTM Designation: C 603, through 3-mm opening at 345 kPa.

Mold briquets in conformance with the requirements in AASHTO Designation: T 132, sawed in half and bonded with a 1.5 mm maximum thickness of sealant and tested in conformance with the requirements in AASHTO Designation: T 132. Briquets shall be dried to constant mass at 100 ± 5° C.

Movement Capability and Adhesion: Prepare 305 mm x 25 mm x 75 mm concrete blocks in conformance with the requirements in ASTM Designation: C 719. A sawed face shall be used for bond surface. Seal 50 mm of block leaving 12.5 mm on each end of specimen unsealed. The depth of sealant shall be 9.5 mm and the width 12.5 mm.

e. R.H. equals relative humidity.

B. Formulate the silicon joint sealant to cure rapidly enough to prevent flow after application on grades of up to 15 percent.

C. Furnish to the Owner a Certificate of Compliance. Accompany certificate with a certified test report of the results of the required tests performed on the sealant material within the previous 12 months prior to proposed use. Provide the certificate and accompanying test report for each lot of silicone joint sealant prior to use on the project.

2.05 ASPHALT RUBBER JOINT SEALANT

A. Conform to the requirements of ASTM Designation: D 3405 as modified herein or to the following:

1. Provide a mixture of paving asphalt and ground rubber. Ground rubber to be vulcanized or a combination of vulcanized and de-vulcanized materials ground so that 100 percent will pass a 2.36-mm sieve and contain not less than 22 percent ground rubber, by mass. Modifiers may be used to facilitate blending.
2. The Ring and Ball softening point shall be 57°C minimum, when tested in conformance with the requirements in AASHTO Designation: T 53.
3. Provide asphalt rubber sealant material capable of being melted and applied to cracks and joints at temperatures below 204°C.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- B. The penetration requirement of Section 4.2 of ASTM Designation: D 3405 do not apply. The required penetration at 25°C, 150g, 5s, shall not exceed 120.
- C. The resilience requirement of Section 4.5 of ASTM Designation: D 3405 do not apply. The required resilience, when tested at 25°C, shall have a minimum of 50 percent recovery.
- D. Accompany each lot of asphalt rubber joint sealant shipped to the job site, whether as specified herein or conforming to the requirements of ASTM Designation D 3405, as modified herein, by a Certificate of Compliance, storage and heating instructions and precautionary instructions for use.
- E. Heat and place in conformance with the manufacturer's written instructions and the details shown on the plans. Provide manufacturer's instructions to the Owner. Do not place when the pavement surface temperature is below 10°C.

2.06 PREFORMED COMPRESSION JOINT SEALANT

- A. Material: ASTM Designation: D 2628.
 - 1. Number of cells: 5 or 6.
 - 2. Lubricant Adhesive: ASTM Designation D 2835.
 - 3. Install compression seals along with lubricant adhesive according to the manufacturer's recommendations. Submit manufacture's recommendations to the Owner's Representative`.
- B. Accompany each lot of compression seal and lubricant adhesive by a Certificate of Compliance, storage instructions and precautionary instructions for use. Also submit the manufacturer's data sheet with installation instructions and recommended model or type of preformed compression seal for the joint size and depth as shown on the plans. Show evidence that the selected seal is being compressed at level between 20 and 50 percent at all times for the joint width and depth shown on the plans.

2.07 BACKER RODS

- A. Provide backer rods that have a diameter prior to placement at least 25 percent greater than the width of the saw cut after sawing and are expanded, crosslinked, closed-cell polyethylene foam that is compatible with the joint sealant so that no bond, adverse reaction occurs between the rod and sealant. In no case use a hot pour sealant that will melt the backer rod. Submit a manufacturer's data sheet verifying that the backer rod is compatible with the sealant to be used.

PART 3 - EXECUTION

3.01 WATER SUPPLY

- A. Conform to Section 40-1.02 of Standard Specifications.

3.02 SUBGRADE

- A. Conform to Section 40-1.04 of Standard Specifications.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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3.03 SOIL STERILANT

- A. Furnish and apply to areas indicated in accordance with Section 31 31 19 – Vegetation Control.

3.04 PLACING

- A. Conform to Section 40-1.06 of Standard Specifications.

3.05 SPREADING COMPACTING AND SHAPING

- A. Conform to Section 40-1.07 of Standard Specifications.
1. Stationary Side Form Construction: Section 40-1.07A of Standard Specifications.
 2. Slip Form Construction: Section 40-1.07B of Standard Specifications.

3.06 INSTALLING TIE BARS

- A. Install at longitudinal contact joints, longitudinal weakened plane joints, and transverse contact joints as shown on the plans. In no case, shall any consecutive width of new portland cement concrete pavement tied together with tie bars exceed 15 meters. In no case shall tie bars be used at a joint where portland cement concrete and asphalt concrete pavements abut.
- B. Tie bars shall be installed at longitudinal joints by one of the 3 following methods:
1. Drilling and bonding in conformance with the details shown on the plans. Provide a two-component, epoxy-resin, conforming to the requirements of ASTM Designation: C 881, Type V. Grade 3 (Non-Sagging), Class shall be as follows:

<u>Temperature of Concrete</u>	<u>Required Class of Epoxy Resin</u>
Lower than 40° F (4.5 °C)	A
40° F (4.5° C) through 60° F (15.5° C)	B
Above 60° F (15.5° C)	C

2. Provide, at least 7 days prior to start of work, a Certificate of compliance and a copy of the manufacturer's recommended installation procedure. The drilled holes shall be cleaned in accordance with the epoxy manufacturer's instructions and shall be dry at the time of placing the epoxy and tie bars. Immediately after inserting the tie bars into the epoxy, the tie bars shall be supported as necessary to prevent movement during the curing and shall remain undisturbed until the epoxy has cured a minimum time as specified by the manufacturer. Tie bars that are improperly bonded, as determined by the Owner, will be rejected. If rejected, adjacent new holes shall be drilled, as directed by the Owner, and new tie bars shall be placed and securely bonded to the concrete. All work necessary to correct improperly bonded tie bars shall be performed at the Contractor's expense.
3. Insert the tie bars into the plastic slip-formed concrete before finishing the concrete. Inserted tie bars shall have full contact between the bar and the concrete. When tie bars are inserted through the pavement surface, the concrete over the tie bars shall be reworked and refinished to such an extent that there is no evidence on the surface of the completed

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

pavement that there has been any insertion performed. Any loose tie bars shall be replaced by drilling and grouting into place with epoxy as described in method 1 above at the Contractor's expense.

4. By using threaded dowel splice couplers fabricated from deformed bar reinforcement material, free of external welding or machining. Threaded dowel splice couplers shall be accompanied by a Certificate of Compliance and installation instructions. Installation of threaded dowel splice couplers shall conform to the requirements of the manufacturer's recommendations.

3.07 JOINTS

- A. Conform to Section 40-1.08 of Standard Specifications, Except that tie bars shall be as specified under Part 2, Products.
 1. Transverse Contact Joints: Section 40-1.08A of Standard Specifications.
 - (a) Construct a transverse contact (construction) joint at the end of each day's work, or where concrete placement is interrupted for more than 30 minutes, to coincide with the next weakened plane joint location.
 - (b) If sufficient concrete has not been mixed to form a slab to match the next weakened plane joint, when an interruption occurs, the excess concrete shall be removed and disposed of back to the last preceding joint. The cost of removing and disposing of any excess concrete shall be at the Contractor's expense. Any excess material shall become the property of the Contractor and shall be properly disposed of.
 - (c) A metal or wooden bulkhead (header) shall be used to form the joint. The bulkhead shall be designed to accommodate the installation of tie bars.
 2. Weakened Plane Joints: Section 40-1.08B, except that the insert method of forming joints in pavement shall not be used.

3.08 FINISHING

- A. Conform to Sections 40-1.09 and 40-1.10 of Standard Specifications.

3.09 CURING

- A. Conform to Section 40-1.11 of Standard Specifications.

3.10 SEALING JOINTS

- A. Liquid Joint Sealant Installation.
 1. The joint sealant detail for transverse and longitudinal joints, as shown on the plans, shall apply only to weakened plane joints. Construct weakened plane joints by the sawing method. Should grinding or grooving be required over or adjacent to any joint after sealant has been placed, completely remove the joint material and disposed of, and replace at the Contractor's expense. Recess sealant below the final finished surface as shown on the plans.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

2. At the Contractor's option, transverse weakened plane joints shall be either Type DSC or Type SSC as shown on the plans. Longitudinal weakened plane joints shall be Type SSC only as shown on the plans.
3. Seven days after the concrete pavement placement and not more than 4 hours before placing backer rods and joint sealant materials, clean the joint walls by the dry sand blast method and other means as necessary to completely remove from the joint all objectionable material such as soil, asphalt, curing compound, paint and rust. After cleaning the joint, remove all traces of sand, dust and loose material from and near the joint for a distance along the pavement surfaces of at least 50 mm on each side of the joint by the use of a vacuum device. Remove surface moisture at the joints by means of compressed air or moderate hot compressed air or other means approved means. Do not use drying procedures that leave a residue or film on the joint wall. Sandblasting equipment shall have a maximum nozzle diameter size of 6 ± 1 mm and a minimum pressure of 0.62-MPa.
4. Install backer rod as shown on the plans. Provide an expanded, closed-cell polyethylene foam backer rod that is compatible with the joint sealant so that no bond or adverse reaction occurs between the rod and sealant. Install backer rod when the temperature of the portland cement concrete pavement is above the dew point of the air and when the air temperature is 4°C or above. Install backer rod when the joints to be sealed have been properly patched, cleaned and dried. Do not use a method of placing backer rod that leave a residue or film on the joint walls.
5. Immediately after placement of the backer rod, place the joint sealant in the clean, dry, prepared joints as shown on the plans. Apply the joint sealant by a mechanical device with a nozzle shaped to fit inside the joint to introduce the sealant from inside the joint. Apply adequate pressure to the sealant to ensure that the sealant material is extruded evenly and that full continuous contact is made with the joint walls. After application of the sealant recess the surface of the sealant as shown on the plans.
6. Any failure of the joint material in either adhesion or cohesion of the material will be cause for rejection of the joint. Conform the finished surface of joint sealant to the dimensions and allowable tolerances shown on the plans. Rejected joint materials or joint material whose finished surface does not conform to the dimensions shown on the plans shall be repaired or replaced, at the Contractor's expense, with joint material that conforms to the requirements.
7. After each joint is sealed, remove all surplus joint sealer on the pavement surface. Traffic shall not be permitted over the sealed joints until the sealant is tack free and set sufficiently to prevent embedment of roadway debris into the sealant.

B. Preformed Compression Joint Seal Installation

1. The compression seal alternative joint detail for transverse and longitudinal joints, as shown on the plans, shall apply only to weakened plane joints. Construct weakened plane joints by the sawing method. Should grinding or grooving be required over or adjacent to any joint after the compression seal has been placed, completely remove the joint materials and disposed of, and replace at the Contractor's expense. Compression seal shall be recessed below the final finished surface as shown on the plans.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

2. At the Contractor's option, transverse weakened plane joints shall be either Type DSC or Type SSC as shown on the plans. Longitudinal weakened plane joints shall be Type SSC only as shown on the plans.
3. Seven days after the concrete pavement placement and not more than 4 hours before placing preformed compression joint seals, clean the joint walls by the dry sand blast method and other means as necessary to completely remove from the joint all objectionable material such as soil, asphalt, curing compound, paint and rust. After cleaning the joint, remove all traces of sand, dust and loose material from and near the joint for a distance along the pavement surfaces of at least 50 mm on each side of the joint by the use of a vacuum device. Remove surface moisture at the joints by means of compressed air or moderate hot compressed air or other means. Do not use drying procedures that leave a residue or film on the joint wall. Sandblasting equipment shall have a maximum nozzle diameter size of 6 ± 1 mm and a minimum pressure of 0.62-MPa.

3.11 PROTECTING CONCRETE PAVEMENT

- A. Conform to Section 40-1.12 of Caltrans Standard Specifications.

END OF SECTION

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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SECTION 32 16 13
CONCRETE CURBS AND GUTTERS

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Concrete curbs and gutters.

1.02 RELATED DOCUMENTS

- A. American Concrete Institute (ACI):

- 1. ACI 301 - Specifications for Structural Concrete for Buildings.
- 2. ACI 308 - Standard Practice for Curing Concrete.

- B. American society for Testing and Materials (ASTM):

- 1. ASTM A 185 - Specification for Steel Welded Wire, Fabric, Plain, for Concrete Reinforcement.
- 2. ASTM A 615 - Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
- 3. ASTM D 1751 - Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).

1.03 DEFINITIONS

- A. ASTM: American Society for Testing Materials

1.04 SUBMITTALS

- A. Submittal procedures shall be as outlined in Section 01 33 00 – Submittal Procedures.
- B. Concrete Mix Design: Have all concrete mixes designed by a testing laboratory and approved by the Owner. Conform all mixes to the applicable building code requirement, regardless of other minimum requirements listed herein or on the drawings. Submit mix designs for review before use. Show proportions and specific gravities of cement, fine and coarse aggregate, and water and gradation of combined aggregates.

1.05 QUALITY ASSURANCE

- A. Concrete shall be subject to quality assurance in accordance with Section 90 of the Standard Specifications.
- B. Certifications:
 - 1. Provide Owner at the time of delivery with certificates of compliance signed by both Contractor and Supplier containing the following statements:

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- (a) Materials contained comply with the requirements of the Contract Documents in all respects.
 - (b) Proportions and mixing comply with the design mix approved by the Consulting Engineer. Design mix shall have been field tested in accordance with the herein requirements of the Standard Specifications and produces the required compressive strength under like conditions.
 - (c) Statement of type and amount of any admixtures.
- 2. Provide Owner, at time of delivery, with certified delivery ticket stating volume of concrete delivered and time of mixing, or time of load-out in case of transit mixers.
- C. Conform to the applicable provisions of Section 51, 73 and 90 of the Standard Specification and these Technical Specifications.
 - 1. Conform construction of portland cement concrete surface improvements (including curbs, gutters, medians, valley gutters, walks) to the requirements of Section 73 of the Caltrans Standard Specifications unless otherwise required in these Technical Specifications or shown on the Plans.
 - 2. Construct "V" ditches in accordance with Section 72-4 of the Standard Specifications; except that finishing shall be in accordance with Standard Specification Section 73 instead of 53, or as otherwise required in these Technical Specifications or shown on the Plans.

1.06 DESIGNATION

- A. General: Whenever the 28-day compressive strength is designated herein or on the Plans is 3,500 psi or greater, the concrete shall considered to be designated by compressive strength. The 28-day compressive strength shown herein or on the plans which are less than 3,500 psi are shown for design information only and are not considered a requirement for acceptance of the concrete. Whenever the concrete is designated by class or as minor concrete herein or on the Plans, the concrete shall contain the cement per cubic yard shown in Section 90-1.01 of the Caltrans Standard Specifications.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Comply with requirements of Section 32 05 23 – Concrete for Exterior Improvements.

2.02 PORTLAND CEMENT CONCRETE

- A. Unless specified otherwise herein or on the Plans, Portland Cement Concrete for items in this section shall be Minor Concrete as specified in Section 90-1.01 of the Standard Specifications.

2.03 CURBS AND GUTTERS FORMS

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- A. Use flexible spring-steel forms or laminated boards to form radius bends. Tolerance: Not to deviate more than 1/4 inch in 10 feet in grade and alignment.

2.04 EXPANSION JOINT MATERIAL

- A. Material for expansion joints in portland cement concrete improvements shall be premolded expansion joint fillers conforming to the requirements of ASTM Designation D 1751. Expansion joint material shall be shaped to fit the cross section of the concrete prior to being placed. Suppliers certificates showing conformance with this specification shall be delivered with each shipment of materials delivered to the job site.
- B. Unless noted otherwise herein or on the Plans expansion joint thickness shall be as follows:
 - 1. Curbs, Curb Ramps, Island Paving, Driveways and Gutter Depressions: 1/4-inch.

PART 3 - EXECUTION

3.01 GENERAL

- A. Comply with requirements of Section 32 05 23 – Concrete for Exterior Improvements.
- B. Form, place and finish concrete walkways, island paving, valley gutters and driveway approaches in conformance with the applicable requirements of Section 73-1.04 and 73-1.06 of the Standard Specifications as modified herein.
- C. Construct new concrete curb, curb and gutter and valley gutters against existing asphalt concrete by removing a minimum of 12-inches of the asphalt concrete to allow placement of curb or gutter forms. Patch pavement with a 6-inch deep lift of asphalt concrete after gutter form is removed.

3.02 SUBGRADE

- A. Conform to Section 40-1.04 of Standard Specifications.

3.03 SOIL STERILANT

- A. Furnish and apply to areas indicated in accordance with Section 31 31 19 – Vegetation Control.

3.04 PLACING CONCRETE FORMS

- A. Form concrete improvements with a smooth and true upper edge. Side of the form with a smooth finish shall be placed next to concrete. Construct forms rigid enough to withstand the pressure of the fresh concrete to be placed without any distortion.
- B. Thoroughly clean all forms prior to placement and coat forms with approved form oil in sufficient quantity to prevent adherence of concrete prior to placing concrete.
- C. Carefully set forms to the alignment and grade established and conform to the required dimensions. Rigidly hold forms in place by stakes set at satisfactory intervals. Provide sufficient clamps, spreaders and braces to insure the rigidity of the forms.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- D. Provide forms for back and face of curbs, lip of gutters and edge of walks, valley gutters or other surface slabs that are equal to the full depth of the concrete as shown, noted or called for on the Plans. On curves and curb returns provide composite forms made from benders or thin planks of sufficient ply to ensure rigidity of the form.

3.05 PLACING STEEL REINFORCEMENT

- A. Bars shall be free of mortar, oil, dirt, excessive mill scale and scabby rust and other coatings of any character that would destroy or reduce the bond.
- B. Accurately place reinforcement as shown on the plans and hold firmly and securely in position by wiring at intersections and splices, and by providing precast mortar blocks or ferrous metal chairs, spacers, metal hangers, supporting wires, and other approved devices of sufficient strength to resist crushing under applied loads. Provide supports and ties of such strength and density to permit walking on reinforcing without undue displacement.
- C. Place reinforcing to provide the following minimum concrete cover:
 - 1. Surfaces exposed to water: 4-inches.
 - 2. Surfaces poured against earth: 3-inches.
 - 3. Formed surfaces exposed to earth or weather: 2-inches.
 - 4. Slabs, walls, not exposed to weather or earth: 1-inch.
- D. Minimum spacing, center of parallel bars shall be two and one half (2-1/2) times the diameter of the larger sized bar. Accurately tie reinforcing securely in place prior to pouring concrete. Placing of dowels or other reinforcing in the wet concrete is not permitted.

3.06 PLACING PORTLAND CEMENT CONCRETE

- A. Thoroughly wet subgrade when concrete is placed directly on soil. Remove all standing water prior to placing concrete.
- B. Do not place concrete until the subgrade and the forms have been approved.
- C. Convey concrete from mixer to final location as rapidly as possible by methods that prevent separation of the ingredients. Deposit concrete as nearly as possible in final position to avoid re-handling.
- D. Place and solidify concrete in forms without segregation by means of mechanical vibration or by other means as approved by the Owner. Continue vibration until the material is sufficiently consolidated and absent of all voids without causing segregation of material. The use of vibrators for extensive shifting of fresh concrete will not be permitted.
- E. Concrete in certain locations may be pumped into place upon prior approval by the Owner. When this procedure requires redesign of the mix, such redesign shall be submitted for approval in the same manner as herein specified for approval of design mixes.

3.07 EXPANSION JOINTS

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- A. Construct expansion joints incorporating premolded joint fillers at twenty (20) foot intervals in all concrete curbs, gutters, median/island paving, valley gutters, driveway approaches and at the ends of all returns. At each expansion joint install one-half inch by twelve inch (1/2" x 12") smooth slip dowels in the positions shown or noted on the detail drawings.

3.08 WEAKENED PLANE JOINTS

- A. Construct weakened plane joints in concrete curbs, gutters, median/island paving and valley gutters between expansion joints at ten (10) foot intervals throughout, or as otherwise indicated. Depth of joint score depth to be one-fourth (25%) the thickness of the concrete.
- B. Grooved Joints: Form weakened plane joints after initial floating by grooving and finishing each edge of joint to a radius of 1/8-inch. Repeat grooving of weakened plane joints after applying surface finishes. Eliminate groover tool marks on concrete surfaces.

3.09 FINISHING CONCRETE

- A. Finish curb and gutter in conformance with the applicable requirements of Section 73-1.04 and 73-1.05A of the Standard Specifications as modified herein.
- B. Where monolithic curb, gutter and sidewalk is specified, separate concrete pours will not be allowed.
- C. Provide a medium broom finish to all horizontal surfaces unless otherwise shown.

3.10 FORM REMOVAL

- A. Remove forms without damage to the concrete. Remove all shores and braces below the ground surface, before backfilling.
- B. Do not backfill against concrete until the concrete has developed sufficient strength to prevent damage.
- C. Leave edge forms in place at least 24 hours after pouring.

3.11 CONNECTING TO EXISTING CONCRETE IMPROVEMENTS

- A. New curb or gutter is to connect to existing improvements to remain by saw cutting to existing sound concrete at the nearest score line, expansion joint or control joint. Drill and insert ½-inch diameter by 12-inch long dowels at 24-inches on center into existing improvements. Install pre-molded expansion joint filler at the matching joint.
- B. A cold joint to the existing curb is not acceptable.

3.12 FIELD QUALITY CONTROL

- A. Conform the finish grade at top of curb, flow line of gutter, and the finish cross section of concrete improvements to the design grades and cross sections.
- B. Variation of concrete improvements from design grade and cross section as shown or called for on the plans shall not exceed the tolerances established in Sections 73-1.05 and/or 73-1.06 of the Standard Specifications.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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3.13 RESTORATION OF EXISTING IMPROVEMENTS

- A. Replace in kind all pavement or other improvements removed or damaged due to the installation of concrete improvements.
- B. Remove, landscaping or plantings damaged or disturbed due to the installation of concrete improvements. Replace in kind.

END OF SECTION

SECTION 32 31 40
HIGH SECURITY FENCES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. High security fences, gates and accessories.

1.2 RELATED REQUIREMENTS

- A. Temporary Construction Fence: Section 01 00 00, GENERAL REQUIREMENTS.
- B. Concrete Footings: Section 03 30 00, CAST-IN-PLACE CONCRETE.
- C. Physical Access Control System: Section 28 13 00 - PHYSICAL ACCESS CONTROL SYSTEM.

1.3 APPLICABLE PUBLICATIONS

- A. Comply with references to extent specified in this section.
- B. ASTM International (ASTM):
1. A653/A653M-15e1 - Steel Sheet, Zinc-Coated (Galvanized) or Zinc Alloy-Coated (Galvannealed) by Hot-Dip Process.
 2. A924/A924M-14e1 - General Requirements for Steel Sheet, Metallic Coated by the Hot-dip Process.
 3. D2794-93(2010) - Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
 4. F2408-16 - Ornamental Fences Employing Galvanized Steel Tubular Pickets.
- C. Master Painters Institute (MPI):
1. No. 18 - Primer, Zinc Rich, Organic.

1.4 SUBMITTALS

- A. Submittal Procedures: Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Submittal Drawings:
1. Show size, configuration, and fabrication and installation details.
- C. Manufacturer's Literature and Data:
1. Description of each product.
- D. Certificates: Certify each product complies with specifications.
1. Fence alignment.
 2. Zinc-coating complies with specifications.
 3. Structural characteristics comply with indicated and criteria on Drawings.
 4. Connections comply with requirements indicated on Drawings.

- E. Qualifications: Substantiate qualifications comply with specifications.
 - 1. Manufacturer with project experience list.
 - 2. Installer with project experience list.
 - 3. Welders and welding procedures.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
 - 1. Regularly manufactures specified products.
 - 2. Manufactured specified products with satisfactory service on five similar installations for minimum five years.
 - a. Project Experience List: Provide contact names and addresses for completed projects.
- B. Installer Qualifications: Manufacturer authorized installer.
 - 1. Regularly installs specified products.
 - 2. Installed specified products with satisfactory service on five similar installations for minimum five years.
 - a. Project Experience List: Provide contact names and addresses for completed projects.
- C. Welders and Welding Procedures Qualifications: AWS D1.1/D1.1M.

1.6 DELIVERY

- A. Deliver products in manufacturer's original sealed packaging.
- B. Mark packaging, legibly. Indicate manufacturer's name or brand, type, color, production run number, and manufacture date.
- C. Before installation, return or dispose of products within distorted, damaged, or opened packaging.

1.7 STORAGE AND HANDLING

- A. Store products indoor in dry, weathertight facility.
- B. Protect products from damage during handling and construction operations.

1.8 FIELD CONDITIONS

- A. Field Measurements: Verify field conditions affecting high security fence fabrication and installation. Show field measurements on Submittal Drawings.
 - 1. Coordinate field measurement and fabrication schedule to avoid delay.

1.9 WARRANTY

- A. Construction Warranty: FAR clause 52.246-21, "Warranty of Construction."

PART 2 - PRODUCTS**2.1 SYSTEM PERFORMANCE**

- A. System components includes pickets, pales, mesh, fabric, rails, posts, gates and hardware required with following performance requirements:
 - 1. Steel Yield Strength: ASTM A924, minimum 344 MPa (50,000 psi).
 - 2. Impact Resistance: ASTM D2794, over 6.8 Nm (60 in-lb.) when using 0.625 ball forward impact.
- B. Gates: Design to meet same forced entry and anti-climb characteristics as other portions of fence.

2.2 MATERIALS

- A. Zinc-Coated Steel: ASTM A653, G90 coating designation ASTM A924.
- B. Tubular Steel: ASTM F2408.
- C. Concrete: As specified in Section 03 30 00, Cast-in-Place Concrete.

2.3 PRODUCTS - GENERAL

- A. Provide fence components from one manufacturer.
- Steel Recycled Content: 30 percent total recycled content, minimum.

2.4 HIGH SECURITY FENCE

- A. Pickets: Hot-dip galvanized steel, nominal 68.75 mm (2 3/4 inches) by 18.75 mm (3/4 inch) by 1.98 mm (0.078 inch) thick unless specified by structural drawings.
- B. Rails: Hot-dip galvanized steel, nominal 50 mm (2 inch) square.
- C. Gate Posts: Tubular steel, nominal 100 mm 4 inch) square.
 - 1. Provide hinged pedestrian gates

2.5 FABRICATION

- A. Fabricate fence and gate to profile and dimensions indicated on Drawings.
- B. Fabricate components with joints tightly fitted and secured.

2.6 FINISHES

- A. Steel Paint Finish:
 - 1. Powder-Coat Finish: Manufacturer's standard two-coat finish system as follows:
 - a. One coat primer.
 - b. One coat thermosetting topcoat.

- c. Dry-film Thickness: 0.05 mm (2 mils) minimum.
- d. Color: As selected by Architect.
- B. Finish exposed surfaces after fabrication.

2.7 ACCESSORIES

- A. Accessories: Manufacturer's required accessories for complete installation.
- B. Barrier Coating: ASTM D1187/D1187M.
- C. Welding Materials: AWS D1.1/D1.1M, type to suit application.
- D. Fasteners: Fasteners as recommended by manufacturer.
- E. Gate Hardware: Fence manufacturers standard hardware for motorized sliding gates.
- F. Galvanizing Repair Paint: MPI No. 18.
- G. Touch-Up Paint: Match shop finish.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Examine and verify substrate suitability for product installation.
- B. Protect existing construction and completed work from damage.
- C. Remove existing gates to permit new installation.
 - 1. Dispose of removed materials.

3.2 INSTALLATION - GENERAL

- A. Install products according to manufacturer's instructions and approved submittal drawings.
 - 1. When manufacturer's instructions deviate from specifications, submit proposed resolution for Contracting Officer's Representative consideration.
- B. Excavate for concrete-embedded items.
- C. Set posts in concrete foundation with a minimum depth of 914 mm (36 inches).
- D. Attached fence panel to the line and end posts with manufacturer's standard fasteners.
- E. Install gate to gate posts spaced as indicated on Drawings. Install required hardware and adjust for smooth operation.
- F. Touch up damaged factory finishes.
 - 1. Repair galvanized surfaces with galvanized repair paint.
 - 2. Repair painted surfaces with touch up primer.

3.3 CLEANING

- A. Clean exposed high security fence and gate surfaces. Remove contaminants and stains.

3.4 PROTECTION

- A. Protect high security fences and gates from traffic and construction operations.
- B. Remove protective materials immediately before acceptance.
- C. Repair damage.

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Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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SECTION 32 84 00
PLANTING IRRIGATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Programmable fully automatic irrigation system with full and complete 100 percent coverage within areas indicated on drawings.
2. Sleeving irrigation pipes and wires as indicated, and beneath hardscape surfaces.
3. Manufacturer of primary irrigation equipment including but not limited to sprinklers, controllers, control valves, weather station and decoders shall be compatible with the existing components on the property.

1.2 RELATED REQUIREMENTS

- A. Maintenance of Existing Utilities: Section 01 00 00, GENERAL REQUIREMENTS.
- B. As-Built Drawings: Section 01 00 00, GENERAL REQUIREMENTS.
- C. Availability and Use of Utility Services: Section 01 00 00, GENERAL REQUIREMENTS.
- D. Submittals: Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- E. Concrete: Section 03 30 53, CAST-IN-PLACE CONCRETE (SHORT FORM).
- F. Excavation, Backfill: Section 31 20 00, EARTH MOVING.
- G. Electrical supply and connection to irrigation controller : Section 26 05 00, COMMON WORK RESULTS FOR ELECTRICAL.
- H. Spigot: Section 323000, SITE FURNISHINGS.
- I. Water Distribution Systems: Section 33 10 00, WATER UTILITIES.
- J. Irrigation Pressure Booster System: Section 32 82 00, IRRIGATION PUMPS.
- K. Plants, Turf, and Grasses: Section 32 90 00, PLANTING.

1.3 DEFINITIONS

- A. Lateral Piping: Piping located downstream from control valves to sprinklers, specialties, and lateral line drain valves. Piping is under pressure during flow.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- B. Mainline Piping: Located downstream from point of connection to water distribution piping to, and including, control valves. Piping is under system pressure.
- C. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 Volts or for remote-control, signaling power-limited circuits.
- D. Hardscape: Site roads, walks, walls, or any other surface improvements for which removal for excavation to perform maintenance or replacement of the irrigation system pipes, or wires will require disturbance of other than landscape materials.
- E. RE: Contracting Officer's Representative (COR).
- F. COR: Contracting Officer's Technical Representative.

1.4 APPLICABLE PUBLICATIONS

- A. Comply with references to extent specified in this section.
- B. American National Standard Institute (ANSI).
 - 1. B40.1-05 - Gauges-Pressure Indicating Dial Type-Elastic Element.
- C. American Society of Sanitary Engineers (ASSE).
 - 1. 1013-2005 - Reduced Pressure Principle Backflow Preventers.
- D. ASTM International (ASTM).
 - 1. A36/A36M-14 - Carbon Structural Steel.
 - 2. A53/A53M-12 - Pipe, Steel, Black and Hot-Dipped, Zin-Coated, Welded and Seamless.
 - 3. A242/A242M-04 (2009) - High Strength Low-Alloy Structural Steel.
 - 4. A307-14 - Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength.
 - 5. A536-84 (2009) - Ductile Iron Castings.
 - 6. B33-10(2014) - Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes.
 - 7. B61-08 - Steam or Valve Bronze Castings.
 - 8. B62-09 - Composition Bronze or Ounce Metal Castings.
 - 9. B584-14 - Copper Alloy Sand Casting for General Applications.
 - 10. D1785-15 - Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedule 40, 80, and 120.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

11. D1238-04c - Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer.
 12. D1784-11 - Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
 13. D1785-06 - Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, 120.
 14. D2241-15 - Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
 15. D2464-15 - Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
 16. D2466-15 - Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
 17. D2564-12 - Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.
 18. D3139-98 (2005) - Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
 19. D3261-15 - Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
 20. D3350-10 - PE Pipe & Fittings Materials.
 21. F477-14 - Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
 22. F656-15 - Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings.
- E. American Water Works Association (AWWA).
1. C110/A21.10-08 - Ductile-Iron and Gray-Iron Fittings, 3 inch Through 48 inch for Water.
 2. C111/A21.11-06 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 3. C115/A21.15-05 - Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
 4. C151/A21.51-09 - Ductile-Iron Pipe, Centrifugally Cast.
C153/A21.53-00 - Ductile-Iron Compact Fittings for Water Service.
 5. C504-15 - Rubber Seated Butterfly Valves.
 6. C509-09 - Resilient-Seated Gate Valves for Water Supply Service.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

7. C600-10 - Installation of Ductile Iron Water Mains and Their Appurtenances.
 8. C900-07 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fitting, 100 mm and Through 300mm (4 In. Through 12 inches) for Water Transmission and Distribution.
 9. C901-08 - Polyethylene (PE) Pressure Pipe and Tubing, 13 mm (1/2 inches) through 76 mm (3 inches), for Water Service.
 10. C905-10 - Polyvinyl Chloride (PVC) Water Transmission Pipe, Nominal Diameters 14 In. Through 48 In. (350 Through 1,200 mm) for Water Transmission and Distribution.
- F. Manufacturers Standardization Society (MSS).
1. SP70-2006 - Cast Iron gate Valves, Flanged and Thread Ends.
- G. National Electrical Manufacturers Association (NEMA).
1. 250-2008 - Enclosures for Electrical Equipment (1000 Volts Maximum).

1.5 PREINSTALLATION MEETINGS

- A. Conduct preinstallation meeting minimum 30 days before beginning Work of this section.
1. Required Participants:
 - a. COR (COR).
 - b. Architect/Engineer.
 - c. Contractor.
 - d. Installer.
 - e. Manufacturer's field representative.
 - f. Other installers responsible for adjacent and intersecting work.
 2. Meeting Agenda: Distribute agenda to participants minimum 3 days before meeting.
 - a. Installation schedule.
 - b. Installation sequence.
 - c. Preparatory work.
 - d. Protection before, during, and after installation.
 - e. Installation.
 - f. Terminations.
 - g. Transitions and connections to other work.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- h. Inspecting and testing.
 - i. Other items affecting successful completion.
3. Document and distribute meeting minutes to participants to record decisions affecting installation.

1.6 SUBMITTALS

- A. Submittal Procedures: Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Submittal Drawings:
 - 1. Shop Drawings: Show size, configuration, and fabrication and installation details.
 - 2. Controller Chart:
 - a. Prepare map diagram showing valves, decoders, lateral lines, and control wires and communication cables route location. Identify valves size, station, number and type irrigation type. Submit approved "As-built" drawings before charts are prepared.
 - b. Provide one reduced drawing of actual "as-built" system controller chart, showing area covered by each automatic controller, supplied at maximum size controller door allows. When controller sequence is not legible when Drawing is reduced to door size, enlarge drawing to readable size and place folded in sealed plastic container, inside controller door.
 - c. Print chart with different color used to show area of coverage for each station. Charts must be completed and approved before final inspection of the irrigation system.
 - 3. Irrigation point-of-connection showing pipe and valve sizes and lay lengths within specified vaults.
 - 4. Irrigation control panel showing all components of control system, location and layout within control cabinet.
 - 5. Show sizes of irrigation zones in GPM based on flow rates of actual irrigation outlets submitted and approved. Size valves for actual

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

demand in GPM not exceeding manufacturer's recommendations for valves with pressure-regulating option.

6. Flower Water Station Spigot Connection Assembly and Curb Stop Valve.

7. Any other detailing through shop drawings indicated in the Drawings.

C. Manufacturer's Literature and Data:

1. Description of each product.

2. Gear-driven rotor sprinkler heads indicating manufacturer recommendation for each application.

a. Include Center for Irrigation Technology Space Pro Single Leg Profile showing Distribution Uniformity and Scheduling Coefficient for nozzles being used at specified spacing.

b. Provide computer generated distribution uniformity and scheduling coefficient calculations for nozzles used at specified spacing.

3. Controllers.

4. Valves.

5. Installation instructions.

6. Warranty.

D. Materials List:

1. Pipe and fittings.

2. Valves.

3. Mainline components.

4. Water filtration components.

5. Electrical components.

6. Control system components.

E. Test Reports: Certify each product complies with specifications.

F. Operation and Maintenance Data:

1. Care instructions for each exposed finish product.

2. Start-up, maintenance, troubleshooting, emergency, and shut-down instructions for each operational product.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Regularly manufactures specified products.

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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2. Manufactured specified products with satisfactory service on five similar installations for minimum five years.
 - a. Project Experience List: Provide contact names and addresses for completed projects.
- B. Installer Qualifications: Product manufacturer or Manufacturer authorized installer.
 1. Regularly installs specified products.
 2. Installed specified products with satisfactory service on five similar installations for minimum five years.
 - a. Project Experience List: Provide contact names and addresses for completed projects..
- C. Welders and Welding Procedures Qualifications: AWS D1.1/D1.1M., AWS D1.2/D1.2M and AWS D1.3/D1.3M.
- D. Products Criteria:
 1. Multiple Units: When two or more units, same type or class of materials or equipment required, provide compatible products from one manufacturer.
 2. Assembled Units: Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for final assembled product.
 - a. All components of assembled unit need not be products of same manufacturer but component parts which are alike are product of single manufacturer.
 - b. Components are compatible with each other and with total assembly for intended service.
- E. Codes and Regulations:
 1. Comply with latest edition of National Electrical Code, Uniform Plumbing Code, and applicable laws and regulations of governing authorities.

1.8 WARRANTY

- A. Construction Warranty: FAR clause 52.246-21, "Warranty of Construction."

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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B. Manufacturer's Warranty: Warrant irrigation materials against material and manufacturing defects.

1. Warranty Period: One year.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. System Requirements:

1. Full (head to head plus 10-percent) and complete coverage of irrigated areas. Adjust head locations as required to achieve full coverage of irrigated areas.
2. Layout work as shown on the drawings. Drawings are diagrammatic to the extent that swing joints, offsets and fittings are not shown. Diagrammatic also refers to the location of the pipelines and valves, which may have been adjusted for clarity of Drawings. Lines are to be common trenched wherever possible. Place irrigation heads shown along roadways between 15 cm (6 inches) and 30 cm (12 inches) from edge of pavement, unless otherwise specified.
3. Locations of remote control valves is schematic. Group remote control valves wherever possible and align at set dimension back of curb along roads. Locate remote control valves individually or in groups of two. Where exact location for valves has not been set, or there are conflicts, coordinate location with COR before installation.
4. Run irrigation lines and control wire thru designated utility lanes or beside roadways.
5. Run irrigation lines, control wires and power wires in trenches as indicated on Drawings or as typical for industry standards, when not indicated.
6. Connect new system to existing mains.
7. Unless noted otherwise, run irrigation lines, power wires and control wires in sleeves or conduit where installed beneath any site hardscape materials.

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 by a qualified testing agency, and marked for intended location and application. Run irrigation lines, cables, control wires, and high voltage conduits in separate sleeves.
- C. Completely program central controller and satellite controllers according to approved master irrigation schedule.
- D. Follow manufacturer's instructions for installation.
- E. Submit manufacturer's written certification that Control System is complete, including related components, and fully operational to COR.

2.2 SYSTEM PERFORMANCE

- A. Design irrigation system complying with specified performance:
 - 1. Minimum Working Pressure Program landscape irrigation pump station settings by the selected irrigation installer to maintain system pressure of minimum 90 psi dynamic while minimum two stations of similar water use volume are in simultaneous operation including stations at or near the furthest uphill interval from the irrigation system point of connection. Do not allow programming of control station to exceed 105 psig. Station-specific pressure regulation shall occur at each control valve and shall be set by the selected irrigation installer to the optimum or manufacturer recommended operating pressure of the associated irrigation emission devices downstream of each control valve.
 - 2. Minimum Design Pressures:
 - a. Irrigation Mainline Piping: 1380 kPa (200 psig).
 - b. Lateral Piping: 1380 kPa (200 psig).
 - c. Valves: 1380 kPa (200psig) WOG.

2.3 MATERIALS

- A. Use new materials without flaws or defects.

2.4 PRODUCTS - GENERAL

- A. Provide each product from one manufacturer.

2.5 PIPE AND FITTINGS

- A. Irrigation Main Pipe:

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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1. Ductile Iron Pipe: AWWA C151, minimum working pressure 1025 kPa (150 psi), cement lined, exterior bituminous coated.
 2. Polyvinyl Chloride (PVC) Pressure Pipe: ASTM D1784, PVC 1120, SDR 21 minimum working pressure 1375 kPa (200 psi), gasketing conforming to ASTM F477. Pipe outside diameters, comply with AWWA C151 cast iron pressure pipe to accommodate cast iron fittings.
 3. Polyvinyl Chloride (PVC) Pressure Pipe: ASTM D1784, Class 200, SDR-21, rated at 1375 kPa (200 psi), gasketing conforming to ASTM F477.
 4. High Density Polyethylene (HDPE) pipes: AWWA C901. Pipe and fittings PE 3408 HDPE resin compound meeting cell classification 345434C, ASTM D3350; and Type 111, Class C, Category 5, Grade P34, ASTM D1238.
 5. Mainline Pipe Within Sleeves: Provide restrained casing spacers for gasketed joints.
- B. Irrigation Main Fittings:
1. Ductile Iron Pipe Fittings:
 - a. Mechanical Joint Fittings: ANSI A 21.10 (AWWA C110) and ANSI A21.11 (AWWA C111).
 - b. Flanged Fittings: ANSI/AWWA C110 and ANSI B16.1 850 kPa(125 lbs.).
 - c. Push-On Joints: ASTM D3139 for Laboratory Qualifying Tests. Use push-on rubber-gasketed ductile iron fittings.
 - d. Gaskets: ASTM F477, rubber.
 - e. Joint Restraints: Class 350 Ductile Iron per ASTM A536.
 2. PVC Pipes Fittings:
 - a. Mechanical Joint Fittings: ANSI A 21.10 (AWWA C110) and ANSI A21.11 (AWWA C111).
 - b. Flanged Fittings: ANSI/AWWA C110 and ANSI B16.1 850 kPa(125 lbs.).
 - c. Gaskets: ASTM F477, rubber.
 - d. Joint Restraints: Class 350 Ductile Iron per ASTM A536.
 3. High Density Polyethylene (HDPE) Fittings:
 - a. Butt, Heat-Fusion Fittings: ASTM D3261.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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C. Lateral Pipe:

1. PVC Pipe: ASTM D1784 Rigid, Unplasticized (PVC) 1120, Class 12454-A or 12454-B, with integral bell end suitable for solvent welding.
2. Pressure Rated PVC Pipe: ASTM D2241, Class 200, SDR-21, 1375 kPa(200 psi) pressure rating.
3. PVC Pipe: ASTM D2466 and D1784.
4. Threaded Pipe: ASTM D1785, PVC 1120, Schedule 80 threaded connections, risers and swing joints. Pipe Above Grade and in Concrete Structures: Ductile Iron meeting AWWA C600, AWWA C115, flanged joints and fittings, working pressure 1025 kPa (150 psi).

D. Lateral Fittings:

1. Irrigation Laterals: ASTM D2466 PVC, Schedule 40, solvent welded socket type.
2. Threaded Pipe: ASTM D2464, PVC, Schedule 80.
3. Swing Joints: Manufacturer's standard with elastomeric seal, allows 360 degree rotation, minimum 1375 kPa (200 psig) working pressure.

E. Joining Materials:

1. Irrigation Mains: Rubber gaskets, AWWA C111.
2. Irrigation Laterals: ASTM D2466 and D1784 PVC Schedule 40, Type 1, solvent weld fittings.
 - a. Primer: ASTM F656.
 - b. Solvent Cement: ASTM D2564.
3. Threaded pipes: Teflon-type tape or Teflon based paste pipe joint sealant. Use non-hardening, non-toxic pipe joint sealant for water-carrying pipes on metal threaded connections.

2.6 SLEEVES

- A. Sleeves: ASTM D1784 Rigid, Unplasticized (PVC) 1120, Class 12454-A or 12454-B, with integral bell end.
1. Pipes Larger than 300 mm (12 inch): AWWA C905, DR-18 rated at 1615 kPa (235 psi).

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- 2. Pipes Smaller than 300 mm (12 inch): ASTM D2241, Class 200, SDR-21 or AWWA C905, DR-25 rated at 1375 kPa (200 psi). or AWWA C900, rated at 1375 kPa (200 psi).
- B. Size: As indicated on Drawings or twice nominal pipe diameter when not shown. Wiring bundle area not exceeding 40 percent of sleeve cross sectional area, according to NEC recommendations.
- C. Restrained Casing Spacers: ASTM A536, Grade 65-45-12 high strength ductile iron.
 - 1. Restraining Rods: ASTM A242 and ANSI/AWWA C111/A21.11, high strength low alloy material.
 - 2. Runners: ASTM D-1894, ultra-high molecular weight polymer, 175-350 Joules/cm (600-1200 ft-lbs./in.) tensile impact and coefficient of friction 0.14-0.17.

2.7 RESTRAINTS

- A. Self-Restrained Fittings: Meeting ANSI/AWWA C153/A21.53 "Ductile-Iron Compact Fittings For Water Service" or ANSI/AWWA C110/A21.10 "Ductile-Iron and Gray-Iron Fittings, 76 mm through 1219 mm (3 inches through 48 inches), For Water".
 - 1. Provide on rubber gasketed pipe pipes 75 mm (3 inch) diameter or larger.
 - 2. Size: As indicated on Drawings.
- B. Thrust Blocks: Concrete, 20 MPa (3,000 psi), 50 micrometers (2-mil) plastic and 12.7 mm (No. 4) rebar wrapped or painted with asphalt tar based mastic coating.
 - 1. Provide on pipe fittings greater than or equal to 75 mm (3 inch) diameter or rubber gasketed pipe.
 - 2. Size: As indicated on Drawings.
- C. Joint Restraint Harness: Provide joint restraint harness where joints not positively restrained by flanged fittings, threaded fittings, or retainer glands and thrust blocks.
 - 1. Provide in ductile iron fittings 76 mm (3 inch) and larger, transition fittings between metal and PVC pipe, where thrust

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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block is not allowed, or where extra support is required to retain fitting or joint.

2. Provide joint restraint harness or retainer glands with preset torque shearing set screws on mainline gate valve assemblies 76 mm (3 inch) and larger.
3. Provide stainless steel bolts, nuts, retaining clamps, all-thread, or other joint restraint harness materials retainer, ASTM A536, and high strength, low alloy steel bolts and connecting hardware, ANSI/AWWA C111/A21.11.

2.8 MAINLINE COMPONENTS

A. Valves (Except Remote Control Valves):

1. Underground Shut-Off Valves:

- a. Gate Valves 50 mm (2 inches) and Larger: AWWA C509, iron body, bronze mounted, double disc with parallel or inclined seats, non-rising stem turning clockwise to close, 1375 kPa (200 psi) minimum working pressure.
- b. Butterfly Valves 80 mm (3 inches) and Larger: AWWA C504, cast iron body with stainless steel shaft, ductile iron valve disc and resilient rubber coated, 1375 kPa (200psi) minimum pressure.

2. Check Valves: Swing.

- a. Smaller than 100 mm (4 inches): ASTM B61 or B62, bronze body and bonnet, 850 kPa (125 pound) WSP.
- b. Larger than 100 mm (4 inches): Iron body, bronze trim, vertical or horizontal installation, flange connection, 1375 kPa (200 pound) WOG.

3. Pressure Reducing Valve:

- a. Cast steel body, renewable seats, stainless steel trim, high velocity components. ASSE: Certified 1003-2027, Threaded Union inlet and outlet, Cast bronze valve body meeting ASTM B584, Stainless steel 300 Series Internal components and strainer screen.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- b. Adjustable to desired pressure, within range of operation specified.
 - c. Air-Vacuum Relief Valve: Epoxy-coated cast Iron body, polypropylene float, glass fiber reinforced nylon kinetic float, Buna-N seals and O-rings, stainless steel nuts and bolts, pressure range 14 kPa to 1580 kPa (2 psi to 230 psi). Continuous acting combination air and vacuum and air release valve. Cast Bronze body meeting ASTM B584, 300 series Stainless Steel, internal components and springs, maximum working pressure 1200 kPa (175 psi).
4. Bronze Ball Valve with Stainless Steel Handle:
- a. Maximum Pressure: 4140 kPa (600 psi) CWP.
 - b. Federal Specification: WW-V-35C.
 - 1) Type II.
 - 2) Composition BZ.
 - 3) Style 3.
5. Master Control Valve:
- a. Body and Cover: Polyester-coated.
 - b. Spring: Stainless steel.
 - c. Diaphragm: Nylon fabric reinforced with rugged insert.
 - d. Bolts, Studs, and Nuts: Zinc-cobalt coated steel.
 - e. Tubing and Fitting Control Accessories: Reinforced plastic and brass.
 - f. Solenoid: 24V AC.
 - g. Operation: Normally closed with automatic control globe valve with contamination-proof, self-flushing filter screen.
 - h. .Pressure Rating: 16 bar (232 psig).
 - i. Operating Pressure Range: 0.5 to 16 bar (7 to 232 psig).
6. Quick Coupling Valve Assembly:
- a. Description: Brass construction, 1 inch nominal size, operating pressure 35-860 kPa (5-125 psi), locking rubber or vinyl cover.
 - b. Swing Joints: Joint with offsets for flexible joints.
 - c. Quick Coupler Anchor: Bolt on anchor type.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- d. Valve Box: Acrylonitrile Butadiene Styrene (ABS) Plastic, 10 inch round valve box with lid color to match location.
 - e. Filter Fabric: Spunbonded polyester 3.5 oz per sq. yard (118.7 grams per sq. m.) landscape fabric.
- B. Flower Water Station Spigot Connection Assembly: As indicated on Drawings.
- 1. Flower Watering Station Spigot: As specified in Section 32 30 00, SITE FURNISHINGS.
 - 2. Curb Stop Valve: ASTM B62, brass body, 2070 kPa (300 psi) minimum working pressure, female threaded connections, with stop and waste feature.
 - 3. Inline pressure regulator: Low lead cast body confirming to ASTM B584, 2750 kPa (400 psi) maximum inlet pressure, with 105 to 515 kPa (15 to 75 psi) adjustable outlet pressure.
 - 4. Copper Pipe: ASTM B88, type "M" soft tubing, wrought copper or cast bronze fittings, soldered, flared mechanical, or threaded joint.
 - a. Solder: 95-percent tin and 5-percent antimony.
 - 5. Valve Box: Concrete curb valve box, cast iron lid, 200 mm ID x 300mm (8 inch ID by 12 inch), face anchored in concrete.
- C. Valve Box:
- 1. Gate and Butterfly Valve:
 - a. Materials:
 - 1) Precast Concrete: Precast concrete, 30 MPa (4000 psi) compressive strength.
 - 2) HDPE: Structural foam Type A, Class III, black, green or tan in color, minimum 475 mm (19 inches) long by 350 mm (14 inches) wide, 305 mm (12 inches) deep, key-lockable hinged lid.
 - b. Cover: Mark box cover, differentiate between lawn irrigation system and domestic water supply system, set flush on finished grade.
 - c. Operations:
 - 1) T-Handle Socket Wrench Operation: Underground valves 50 mm (2 inch) nut.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- 2) Handwheels: MSS SP70 Above ground and in pits.
 - 3) Enclosed Gear Drive Operators: Butterfly valves 150 mm (6 inches) and above.
 - d. Accommodate end valves with type of pipe being installed. Provide mechanical joint ends with self-restrained joints on buried irrigation main valves.
2. Remote Control Valves:
- a. Materials:
 - 1) Precast Concrete: Precast concrete, 30 MPa (4000 psi) compressive strength.
 - 2) HDPE: Structural foam, Type A, Class III.
 - a) Color: Black, Green, or Tan.
 - b) Size: Minimum 475 mm (19 inches) long by 350 mm (14 inches) deep with key-lockable hinged lid.
 - b. After installation, hot brand valve box lid 75 mm (3 inch) high, 1 mm (3/16 inch) deep with permanent white epoxy paint, designating controller and circuit numbers. Place numbers in center of valve cover facing nearest main or service road.
 - c. Provide 750 mm (30 inch) long valve adjustment keys.
3. Drip zone Lateral Flush Cap Assembly: HDPE round reinforced plastic valve box and lid, minimum 14.5 cm (5-3/4 inches) diameter top opening with lift-hole. Access box height, 23cm (9-1/16 inches) minimum.
4. Emitter Access Boxes: HDPE round plastic boxes and lid, color green, or tan, 13 cm (5 inches) minimum top diameter, height 26 cm (10-1/4 inches) minimum.
- D. Backflow Preventer: ASSE 1013, reduced pressure principle, except pressure drop, in each new connection to existing potable water distribution system.
- 1. Design Flow Rate: Maximum 70 kPa (10 psi).
- E. Water Meter Assembly:
- 1. Water Meter:
 - a. Install Utility Company water meter.
 - 2. Water Meter Pit:

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- a. Reinforced poured in place concrete or approved precast concrete.
 - 1) Size: As indicated on Drawings.
 - 2) Rungs: Cast iron or aluminum, asphalt coated when in contact with concrete, free of sharp edges, burrs or projections with slip resistant finish.
 - a) Size: 25 mm (one inch) diameter, 300 mm (12 inches) wide, 175 mm (7 inches) clear space to wall, minimum 65 mm (2 1/2 inch) depth in wall.
 - 3) Reinforced Concrete: Same as above except, minimum 150 mm (6 inches) in wall.
 - 4) Vault Covers:
 - a) Cast iron access cover.
- 3. Frames and Covers: Cast-iron, traffic rated with cast-in identification symbol "WATER".
- 4. Strainers: Brass strainer, basket or "Y" type.
 - a. Size:
 - 1) Body smaller than 70 mm (2-1/2 inch), brass or bronze.
 - b. Body 70 mm (2-1/2 inch) and larger, cast iron or semi-steel.
 - c. Cover: Provide blow-off connection and shut-off valve for 20 mm (3/4 inch) diameter hose connection.
- 5. Pressure Gages: ANSI B40 1, 114 mm (4-1/2 inch) diameter, metal case, oil filled bottom connected with shut-off cocks.
 - a. Dial: Either black or white lacquered throughout. Provide shut-off cocks.
 - b. Maximum graduations: 10 kPa (2 psi).
- 6. Pipe Supports: Corrosion-resistant, galvanized finish.
 - a. Plumbing and mechanical equipment supports for basket strainer, pressure reducing valve and master valve.
 - 1) Flange Cradle: ASTM A36.
 - 2) Collar/Base Cup: ASTM A53 D.O.M tubing.
 - 3) Threaded Stud: ASTM A36; rolled thread; Grade ASTM A307.
 - 4) Base Plate: Sheet steel, 6.5 mm (0.25 inch) plate; ASTM A36.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- 5) Welds: 100 percent MIG. Electrode E70XX.
 - a) Cradle: Radius to CL 125 flange diameter, 120 degree coverage.

7. Backflow Enclosure:

- a. Construction: Vandal-resistant steel tube and wire with a smooth surface.
- b. Coating: performance polymer alloy powder.
- c. Locking Mechanism: Stainless Steel full release.
- d. Warranty: One year.
- e. Powder Coat Color: standard dark green.

2.9 SPRINKLER IRRIGATION COMPONENTS

A. Remote Control Valve Assembly:

- 1. Remote Control Valve: Globe type, heavy construction, manual shut-off and flow control adjustment for manual operation, minimum 1025 kPa (150 psi) working pressure; higher working pressure for systems that operates with working pressures above 140 psi.
 - a. Install underground, operated by a 24-volt AC electric solenoid. Provide unions on both sides of valve. Provide assembly over gravel sump as indicated on Drawings.
 - b. Valves: Brass or plastic construction, straight or angle pattern type, or cast-iron body with brass bonnet, trim and renewable seat, and two inlet tappings (furnished with one plugged) to allow straight or angle pattern valve installation.
 - c. Valves: Diaphragm type, designed to operate water containing sand and debris, self-cleaning type with contamination filter. Incorporate non-adjustable type opening and closing speed control surge pressures protection, or operate by means of slow acting direct drive without ports, screens or diaphragms.
 - d. Provide valves with pressure regulators.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- e. Valves Serviceability: From top without removing valve body from system. Provide 750 mm (30 inch) long adjustment keys. Operate valves maximum 50 kPa (7 psi) pressure loss at manufacturers maximum recommended flow rate.
- 2. PVC Union: Schedule 80 threaded union with O-ring seal.
- 3. Bronze Ball Valve with Stainless Steel Handle:
 - a. Maximum Pressure: 4140 kPa (600 psi) CWP.
 - b. Federal Specification: WW-V-35C.
 - 1) Type II.
 - 2) Composition BZ.
 - 3) Style 3.
- 4. Filter Fabric: Spunbond polyester 3.5 oz. per square yard landscape fabric.
- 5. Wire connectors: Direct burial 600 V maximum voltage. Wire combination size: (2 to 5) 18 AWG to (2) 12 AWG. UL approved. 3M DBY or DBR.
- 6. Identification Tags: Christy I.D. tags. Standard Yellow, one sided. Tag Size: 57 mm by 69 mm (2.25 inch by 2.7 inch), hot stamped black letters on, yellow background. Hot stamp component number code as indicated.
- B. Popup Gear Driven Rotary Sprinkler Assembly: Integral self-closing anti-drain valve, 3.0 m (10 feet) maximum head pressure with removable inlet debris screen.
 - 1. Full Sprinklers:
 - a. Body: Corrosion resistant, impact resistant, heavy-duty ABS outer case.
 - b. Head Type: Dual or tri-nozzle combination positive gear assembly drive on stainless steel spindles in water lubricated sand proof case.
 - 2. Part Circle Sprinklers: Same as full sprinklers above, except variable arc type.
- C. Multi-Stream Rotary Nozzles:
 - 1. Radius and arc as shown on Drawings.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- D. Spray Heads: High impact plastic or brass nozzle with adjusting screw to regulate radius and flow. Heavy-duty stainless steel retracting spring and ratcheting system for pattern alignment. Soft elastomer pressure-activated co-molded wiper seal.
1. Body: Heavy duty, ultraviolet resistant plastic sprinkler body, stem, nozzle, with non-clogging filter and pressure compensating screens (PCS).
 2. Head Type: Pop-up, matched precipitation rate nozzle as shown.
 3. Flow Rate: As indicated on Drawings.
- E. Pressure Compensating Bubblers:
- 1.5 gph as shown. 1.25 cm (1/2 inch) FPT threaded inlet.
- F. Drip Emitters:
1. Emitter Type: Pressure compensating, permanently assembled type, 1.25cm (1/2 inch) FPT inlet.
 2. Flow Rate: 1gpm at inlet pressures between 15 and 50 psi.
 3. Emitter Tubing: UV resistant vinyl, 6mm (0.22 inch) O.D. and 4 mm (0.16 inch) I.D., manufactured by same manufacturer as emitters.
- G. Low Voltage Control Valve Wire:
1. Wire: Solid copper wire, UL LLC approved for direct burial.
 - a. Size: According to manufacturer's instructions, but minimum AWG 14.
 2. Splicing Materials: Epoxy waterproof sealing packet.
 3. Low Voltage Controller Cable: Multi-strand, UL LLC approved for direct burial.
 - a. Number, Size and Type: According to manufacturer's instructions.
 4. Decoder-to-Solenoid (DTS) Cables 14 AWG, solid copper; 2-conductor; Use jacketed wire pairs with colors matching jacketed wires on decoders for connecting decoders to control valves.
- H. Warning Tape: Polyethylene film warning tape, 0.1 mm (4 mils) thick, 75 mm (3 inches) wide, detectable imprinted with "CAUTION BURIED IRRIGATION WATER LINE BELOW", colored as follows:
1. Blue with Black Letters: Potable water.
 2. Purple with Black Letters: Reclaimed or untreated well water.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- I. Tracer Wires: Plastic-coated copper tracer wire, 1.8 mm (14 gage), green, Type TW. Install with non-metallic irrigation main lines.
- J. Decoders for Two-Wire Operation:
1. Decoder: Solid-state design, housed in a watertight molded plastic housing.
 - a. Decoder leads: 18-gauge, insulated, stranded copper.
 - b. Colors as indicated.
 - c. Wire Leads: Minimum of 305 mm (12 inches) long.
 - d. Wire Connections: Watertight electrical connections suitable for the wire type being connected.
 2. Decoders: Mounted underground in separate 305 mm by 457 mm (12 inch by 18 inch) valve boxes, or with remote control valves. Fastened to inside of valve boxes with stainless steel self-tapping screws. Brand valve boxes containing decoders "SP" in 50 mm (2 inch) high letters, painted with permanent white epoxy paint. Place boxes on 457 mm (18 inch) deep bed of pea gravel.
 - a. 26VAC input service provided by the two-wire communication path.
 3. Provide factory pre-coded decoders with 1, 2, or 4 addresses, each activating one remote valve solenoid.
 4. Use 4 address decoders to extent. Include line surge protection.
 5. Provide manufacturer's optional barcode scanner-based decoder programming unit to input decoder addresses. Provide programming unit capable of backing up and restoring programs.
 - a. Field Decoders: TW-D-1 (One station decoder, includes dry splices); TW-D-2 (Two station decoder, includes dry splices); TW-D-4 (Four station decoder, includes dry splices).
 6. Decoder Cable Fuse Device: Paige Electric DCFD 2-way and DCFD3 3-way electrical isolation devices; or approved equal.
 7. Lightning Arrestor: Rain Master TW-LA-1, or approved equal.
 8. Grounding Rods: 16 mm by 2.5 meters (5/8 inch diameter by 8-foot long) copper ground rod, copper clamp and #6 bare copper wire; UL-approved; sized per manufacturer's instructions.
- K. Two-Wire Decoder Cable:

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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1. Two-conductor control cable design consisting of tin coated copper conductors, insulated with PVC and having a high density polyethylene direct burial jacket. Conductors are listed as Type UF by UL or ETL or CSA.
 2. Conductor: Minimum conductor size 14 AWG; soft annealed tin coated solid copper conforming to ASTM B33.
 3. Insulation: Polyvinyl Chloride conforming to UL Standard 493 for TYPE UF rated 60°C.
 4. Cable Assembly: Insulated conductors are laid parallel.
 5. Outer Jacket: Pressure Extruded High Density PE conforming to ICEA S-61-402, and NEMA WC5 Jacket Thickness 1.2 mm (3/64 inch) minimum jacket material to completely fill interstices between the two insulated conductors.
 6. Color Coding: Black, Red.
 7. Jacket Color: Blue. (Use a different jacket color for each controller on the project).
- L. Hard Wire Communication Cable: Direct burial, polymer-coated aluminum shielded, insulated, 1-pair multi-conductor, with polyethylene outer jacket for connecting satellite controllers with each other.
1. Provide two 20 AWG, full braid shield, 100 Ohm impedance. One copper conductor and one silver tinned conductor, black jacket, rated for direct burial shielded communication cable used for hardwire satellite serial link. Cable shall not exceed 5000 feet in length.
 2. All cable must be certified by Rain Master Irrigation systems.
- M. Flow Sensor Cable: Direct-burial, polymer-coated aluminum shielded, insulated, 1-pair multi-conductor, with polyethylene outer jacket for connecting flow sensors with satellite controllers.
1. Two 20 AWG foil shield w/drain, black jacket, rated for direct-burial BLK, WHT. Two conductor direct burial shielded cable used with all field sensor connections to satellites such as flow sensors. Cables not to exceed 609 meters (2000 feet) in length.
 2. Cables must be certified by Rain Master Irrigation systems.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- N. Communication Cable Splice and Cap: A three-part, rigid body closure that self-encapsulates two-and five-pair buried service wire. It has a built-in bonding system that bonds the buried service wire shield as the splice is put together. The special formulated sealant is a one-part, no-mix, non-urethane product containing no grease.
- O. Electrical Conduit and Fittings: High-impact Schedule 40 PVC C-2000 compound, UL approved, gray color, size as required. Solvent-weld fittings.
- P. Pull Rope for Empty Conduits: 1/4 inch diameter, 12-strand, 544 kg (1,200 lb) tensile strength braided polypropylene rope.
- Q. Drainage Backfill: Clean gravel or crushed stone, graded from 6 mm (1/4 inches) minimum to 19 mm (3/4 inch) maximum.
- R. Pipe Bedding and Initial Backfill: Clean sand per Section 31 20 00 EARTH MOVING for trenching and backfilling of utilities.

2.10 CONTROL SYSTEM COMPONENTS

- A. Automatic Central Control Equipment-Field Satellites:
 - 1. Overall Control Concept: Central computer system; contains irrigation starting controls, capable of overriding field satellite units, and operating individual remote control valves according to timing schedules programmed into field units.
 - a. Number of Units and Locations: As indicated on Drawings.
 - 2. Central Computer Control System: Manufacturer's standard components; Central Computer, Master Flow Meter, Leak Detection Flow Meters, Moisture Sensor, ET Measurement Device, Rain Measurement Device, Wind Measurement Device, Field Controller and necessary components and software in standard package supplied by irrigation control manufacturer.
 - a. Modify performance criteria for Central Computer Control System, without indicating manufacturer. Accurately define functioning and operational components.
 - b. Modify where Central Computer Control System match existing system, clarify whether full system replacement of Central and satellites is acceptable instead of matching existing.

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- c. Modify to include function and performance information. Describe how system operates and provide desired leak detection performance. Describe causes of alarm conditions, specify system shut down level which occurs as a result of alarm conditions.
 - d. Specify exactly how new irrigation system components are to be integrated with existing and what modification, replacement, upgrading, etc. is required for the existing system.
 - e. Prepare performance based narrative. describing how system operates in normal automatic conditions; manual conditions; partial shutdown conditions and emergency shut down conditions.
 - f. Prepare performance-based narrative describing water supply source operates in conjunction with irrigation Central Computer equipment.
3. Central Computer Control System:
- a) Controller should be capable of reading flow meter and recording flow for each station. Logging reading for xx water days, including run times, water use, and operational characteristics.
 - b) Receiving and storing on-site, daily ET weather data and accumulated rainfall to automatically determine station run times in minutes.
 - c) Operating multiple master schedules to allow daily, weekly programming.
 - d) Comparing water budget proportionate to historical ET.
 - e) Operating Cycle and Soak watering.
 - f) Containing full, built-in English and Spanish operating manual.
 - g) Detecting electrical faults and bypass, and logging all alerts.
 - h) Programming rain shut down.
 - i) Activating/deactivating master valve control.
 - j) Optional integrated Radio Remote compatible.
 - k) Starting pump.

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- 1) Monitoring flow within operator-set parameters. Built-in transient protection and lightning protection.
- a. Performance Criteria:
 - 1) Identify housing materials.
 - 2) Define pulse output, Voltage and pulse rate proportional to flow.
 - 3) Fully compatible with internal interface of controller.
 - 4) Powered by the controller.
 - 5) Flow meter data can be accurately read by the controller.
 - 6) By the same manufacturer as the irrigation controller.
4. Flow Meter:
 - a. Solid-state tensiometer type.
 - b. Include data transmission circuitry, which sends moisture level readings back to irrigation controller using valve field wires.
 - c. Entire unit encased in epoxy.
 - d. Require no calibration for life of the sensor.
 - e. Unaffected by temperature, salinity or changes in pH.
 - f. Accurately transmit moisture levels.
5. Moisture Sensors:
 - a. Powered by field controller.
 - b. Measures ET directly in 0.01" increments and sends pulses directly to field controller.
 - c. Fully compatible with internal interface at field controller.
 - d. Mounted inside stainless steel, vandal-resistant enclosure specifically designed for the device.
6. ET Measurement Device:
 - a. Accurately measures rainfall in 0.01" increments by means of a tipping and emptying device mounted below center of collection dish.
 - b. Fully compatible with internal interface at field controller.
 - c. Operate between 32 degrees F and 125 degrees F.

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- d. Be constructed of anodized aluminum.

7. Rain Measurement Device:

- a. Accurately define material and operational components.
- b. Powered by field controller.
- c. Accurately measures wind in 0.1 mph increments.
- d. Fully compatible with internal interface at field controller.
- e. Operate between -50 degrees C and + 50 degrees C.
- f. Be constructed of anodized aluminum.
- g. Record wind speeds up to 140 MPH.

8. Wind Measurement Device:

- a. Operates on Windows compatible computer with minimum 16 MB memory.
- b. Requires 300 megabytes hard disk space for program and files.
- c. Functions on any combination of phone, or local radio, or hardware interface.
- d. Allows uploading and downloading programs and log data by controller or groups of controllers.
- e. Has real-time access to run stations and programs, check master valve operation, and operate controllers.
- f. Capable of printing alerts based on operator-set data filters; automatically creating permanent files each time data is uploaded.
- g. Allows program, log, summary and alert data for each controller to be printed selectively.
- h. Capable of automatically uploading weather station, and Rain Bucket and redistributing to field units.
- i. Capable to operate up to 30 controllers.
- j. Capable of automatically retrieving water usage data and writing to text files monthly.
- k. Capable of allowing user override changes.
- l. Communication links or central control system failure cannot affect normal water management operation of field controllers.

9. Central Computer Software.

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EHRM Infrastructure Upgrades-Tier 2

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- a. When using digital radio, radio shall be an internal packet-switched digital radio modem capable of two-way communication on Mobitex public network.
 - b. When using radio, radio modem and all interface boards shall be mounted inside the controller and powered by the same 24VAC internal transformer.
 - c. A vandal-resistant epoxy-filled dome antenna shall be used in any type of radio communication.
10. Field Controllers with Central Communication:
- a. Conduct an on-site radio test with manufacturer to verify satisfactory operation before submitting a bid for radio control.
11. Control System: System consists of Independent controller, and accessories necessary to operate irrigation system. Provide standard package containing these components and software.
- B. Automatic Control Equipment-Solar-powered:
- 1. Overall Control Concept. Solar-powered automatic control system consists of one or more independent controllers operating individual remote control valves according to timing schedules programmed into the independent units. Number of units and location as indicated on Drawings.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Examine and verify substrate suitability for product installation.
- B. Protect existing construction and completed work from damage.

3.2 INSPECTIONS AND REVIEWS

- A. Site Inspections:
 - 1. Verify site conditions and note irregularities affecting work.
Report irregularities to COR before beginning work.
- B. Utility Location ("Call Before You Dig"):
 - 1. Arrange and coordinate underground utility locations with local authorities and cemetery maintenance personnel.

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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2. Repair underground utilities damaged during construction with no increase in contract price.

- C. Irrigation System Layout Review: Stake locations of irrigation system components as defined below for COR's review. Notify the COR one week in advance of review. COR will identify and approve modifications during this review.

3.3 INSTALLATION - GENERAL

- A. Install products according to manufacturer's instructions and approved submittal drawings.
1. When manufacturer's instructions deviate from specifications, submit proposed resolution for COR consideration.
- B. Perform excavation, trenching, and backfilling for sprinkler system as specified in Section 31 20 00, EARTHWORK and as indicated on Drawings.

3.4 LAYOUT OF WORK

- A. Stake alley and sprinklers locations in existing burial sections using a licensed surveyor. Use alleys as indicated on Drawings.
- B. Stake out irrigation system.
- C. When staked irrigation components conflict with utilities or other components or site features, coordinate rerouting of components with COR. To comply with requirements of the following conditions specified herein this specification section to obtain compliance of regulatory regulations.

3.5 SLEEVING AND BORING

- A. Provide and install sleeves where pipe and control wires pass under walks, paving, walls, and other similar areas.
- B. Extend sleeve minimum 300 mm (12 inches) beyond edge of paved surface, wall, etc. Cover pipe ends and mark edge of pavement.
- C. Verify sleeve sizing is adequate before installation. Note that sleeves required for pipe with restrained casing spacers are larger than twice the diameter of the pipe.
- D. Bed sleeves, minimum 100 mm (4 inches) sand backfill above top of sleeve.

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Fargo, North Dakota 58102-2417
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3.6 PIPE AND FITTING ASSEMBLY

A. General:

1. Keep pipe free from dirt and pipe scale. Cut pipe ends square and debur.
2. Cap assembled pipe ends. Remove caps only to continue assembly.
3. Curve trenches to change direction or avoid obstructions within limits of pipe curvature. No deflection allowed at pipe joint. Minimum radius of curvatures as follows:

SIZE	RADIUS	OFFSET PER 6 m (20 feet) LENGTH
38 mm (1 1/2 inches)	7.5 m (25 feet)	2.3 m (7 ft-8 inches)
50 mm (2 inches)	7.5 m (25 feet)	2.3 m (7 ft-8")
63 mm (2 1/2 inches)	30 m (100 feet)	575 mm (1 ft-11 inches)
75 mm (3 inches)	30 m (100 feet)	575 mm (1 ft-11 inches)
100 mm (4 inches)	30 m (100 feet)	575 mm (1 ft-11 inches)
150 mm (6 inches)	45 m (150 feet)	400 mm (1 ft-4 inches)
200 mm (8 inches)	60 m (200 feet)	300 mm (1 ft-0 inch)
250 mm (10 inches)	75 m (250 feet)	225 mm (9 inches)
300 mm (12 inches)	90 m (300 feet)	200 mm (8 inches)

B. Mainline Pipe and Fittings:

1. Plastic Pipe:

- a. Lay pipe "snake fashion" in trench 1 meter to 100 meters (1 foot per 100 feet) to allow for thermal construction and expansion and to reduce strain on connections..
- b. Provide expansion joints every 1525 cm (50') o.c. Install per manufacturer's instructions.
 - 1) Acceptable manufacturer is Spears (S119-XX) or approved equal.
- c. Joints:

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EHRM Infrastructure Upgrades-Tier 2

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- 1) Solvent Welded Socket Type, ASTM D2855.
- 2) Threaded Type: Apply liquid Teflon, thread lubricant. Tighten joint with strap wrench up to two additional full turns after joint is hand tight (hard).
- 3) Elastomeric Gasket: ASTM F477, compatible with bell annular groove.
 - a) Thoroughly clean inside of bell or coupling, outside of spigot, and elastomeric gasket immediately before joining two lengths of PVC pipe.
 - b) Lubricate joint and rubber gasket according to pipe manufacturer's instructions.
 - c) Insert elastomeric gasket in the annular groove of bell or coupling according to the manufacturer's instructions. Mark pipe not furnished with depth mark before assembly and insert to full depth of joint.
 - d) Align spigot and bell or coupling and push until spigot is fully inserted in bell or coupling. Push with smooth steady motion.

2. Ductile Iron Pipe: AWWA C600.

a. Joints:

- 1) Mechanical: AWWA C111. Provide bolts, nuts, glands and gaskets on pipe and fittings socket opening.
- 2) Push on: Apply thin film gasket lubricant and place in proper position in bell contour. Insert bevel end of joining pipe and make contact with gasket. Force pipe bevel end to bottom of bell without displacing gasket. Do not caulk. Use lubricant furnished by pipe manufacturer.
- 3) Flanges: AWWA C115. Install only in concrete pits. Make watertight and set minimum 150 mm (6 inches) from walls or floor.

C. Lateral Pipe and Fittings:

1. PVC Solvent Weld Pipe:

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- a. Use primer and solvent cement. Join pipe according to manufacturer's instructions and accepted industry practices.
 - b. Cure 30 minutes before handling and 24 hours before pressurizing or installing vibratory plow.
 - c. Snake pipe from side to side within trench or install with expansion joints.
 - d. In irrigation isles, coordinate location of monuments to avoid conflicts.
2. Fittings: Cross type fittings is not acceptable.
- D. Emitter hose:
- 1. Use Type 1/11 solvent weld.
 - 2. Use line size by 10 mm (3/8 inch) insert bushings to transition from PVC Schedule 40 fittings to flex-vinyl hose.
- E. Specialized Pipe and Fittings:
- 1. Mechanical Joint Connections: Install fittings, fasteners and gaskets according to manufacturer's instructions and accepted industry practices.
 - 2. PVC Threaded Connections:
 - a. Factory-formed threads. Field-cut threads are not acceptable.
 - b. Apply thread sealant according to manufacturer's instructions and accepted industry practices.
 - c. Use plastic components male threads and metal components female threads for plastic-to-metal connection.
- F. Thrust Blocks:
- 1. Use cast-in-place concrete bearing against undisturbed soil.
 - 2. Size, orientation and placement as indicated in installation details on Drawings.
 - 3. Wrap fitting with plastic protecting bolts, joint, and fitting from concrete.
 - 4. Install rebar with mastic coating as indicated on Drawings.
- G. Joint Restraint Harness:
- 1. Install harness according to manufacturer's instructions and accepted industry practices.

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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2. Use restrained casing spacers for gasketed pipe routed through sleeving. Install self-restraining casing spacers at gasketed pipe bell joints and every 10-feet along gasketed mainline pipe installed through sleeving. Provide correct number and type of restraints per manufacturer's instructions.

3.7 INSTALLATION OF MAINLINE COMPONENTS

- A. General: Install as indicated on Drawings.
- B. Valve for Existing Facilities: Match existing of the same type, unless specifically noted otherwise.
- C. All valves meet or exceed specified parameters identified herein, or parameters for existing valves being matched, whichever provide higher quality product.
- D. Valves Setting:
 1. Install as indicated on Drawings and according to manufacturer's instructions.
 2. Do not set valves under roads, pavement or walks.
 3. Clean valve interior before installation.
 4. Place valves in same valve box where pressure control valves are installed adjacent to remote control valve.
 5. Set valve box cover flush with finished grade.
 6. Brand or cast "GV" in 50 mm (2 inch) high by 5 mm (3/16 inch) deep letters on valve box lid.
- E. Air/Vacuum Relief Valve Assembly:
 1. Install as indicated on Drawings and according to manufacturer's instructions.
 2. Brand "AV" in 2 inch high by 3/16 inch deep letters on valve box lid.
- F. Quick Coupling Valve Assembly:
 1. Install as indicated on Drawings and according to manufacturer's instructions.
 2. Brand "QC" in 2 inch high by 3/16 inch deep letters on valve box lid.
- G. Flower Watering Station Hydrant Connection Assembly:

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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1. Install as indicated on Drawings and according to manufacturer's instructions.
2. Sequence of Construction:
 - a. Coordinate exact location with COR.
 - b. Install components before concrete pad. Coordinate installation with Section 03 30 53, CAST-IN-PLACE CONCRETE (SHORT FORM).
3. Location:
 - a. Install stations at locations indicated on Drawings, centered between adjacent sprinkler locations.
 - b. Route adjacent piping around stations. Do not install mainline or lateral pipe under Flower Watering Stations.
4. Paint "FW" in 2 inch high by 3/16 inch deep letters on valve box lid.

3.8 INSTALLATION OF SPRINKLER IRRIGATION COMPONENTS AND QUICK COUPLERS

- A. Remote Control Valve Assembly: Install as indicated on Drawings and according to manufacturer's instructions.

1. Mainline Flushing:
 - a. Flush mainline before installation of Remote Control Valve Assemblies.
 - b. Identify remote control valve service tees for mainline flushing. Plug service tees not used for flushing.
 - c. Connect 50 mm (2 inch) pipe to flushing service tees, to direct water away from trench and into drainage swale, curb section or storm sewer, away from work area and not disrupt cemetery operations.
 - d. Use water volume 0.9 m/s (3 FPS) velocity in largest pipe flushing.
 - e. Flush multiple points simultaneously.
 - f. Flush minimum 20 minutes. Continue flushing until water is clear of debris.
 - g. COR will review flushing operation and water clarity before stopping flushing operation.

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- h. Disconnect pipe from service tees and install remote control valves.
- 2. Adjust valve to regulate downstream operating pressure as follows:
 - a. Rotor Sprinklers: 480 kPa (70 psi).
 - b. Rotating Stream Nozzles: 310 kPa (45 psi).
 - c. Spray Sprinklers: 240 kPa (35 psi).
- 3. Connect control wires to solenoid wires with wire connectors and waterproof sealant. Install connectors and sealant according to manufacturer's instructions.
- 4. Install only one remote control valve to valve box. Locate valve box 1.5m (5-feet) from and align square from adjacent edges of paved areas.
- 5. Attach ID tag to solenoid with controller station number to control wiring.
- 6. Brand controller and station number in 50 mm (2 inch) high by 5 mm (3/16 inch) deep letters on valve box lid.
- B. PopUp Gear-Driven Rotary Sprinkler Assembly:
 - 1. Flush lateral pipe before installing sprinkler assembly. Clear water of debris before flushing operation stops.
 - 2. Install at locations indicated on drawings.
 - 3. Locate rotary sprinklers 150 mm (6 inches) from adjacent edges of paved areas, walls or fences.
 - 4. Install sprinklers perpendicular to finish grade.
 - 5. Install swing joint as indicated on Drawings.
 - 6. Supply appropriate nozzle or adjust arc coverage of each sprinkler.
 - 7. Adjust each sprinkler throw radius.
 - 8. Install sod 600 mm (2-foot) square around rotary sprinklers in seeded areas.
- C. Spray Sprinkler Assembly:
 - 1. Flush lateral pipe before installing sprinkler assembly. Clear water of debris before flushing operation stops.
 - 2. Install at locations indicated on drawings.
 - 3. Locate rotary sprinklers 150 mm (6 inches) from adjacent edges of paved areas, walls or fences.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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4. Install sprinklers perpendicular to and flush with finish grade.
5. Install swing joint as indicated on Drawings.
6. Supply appropriate nozzle or adjust each sprinkler arc coverage.
7. Adjust each sprinkler throw radius.

D. Sprinkler Heads and Quick Couplers:

1. Place on temporary nipples extending at least 80 mm (3 inches) above finished grade. After turf is established, remove temporary nipples and install sprinkler heads and quick couplers at flush with ground surface ensuring no dirt or foreign matter enters outlet.
2. Place part-circle rotary sprinkler heads maximum 150 mm (6 inches) from edge, of and flush with top adjacent walks, header boards, curbs, and mowing aprons, or paved areas at time of installation.
3. Install shrub sprays, sprinklers, and quick couplers on swing joints as detailed on Drawings.
4. Set shrub heads 200 mm (8 inches) above grade and 300 mm (1 foot) from curb or pavement edges. Place adjacent to walls. Stake heads parallel to riser before backfilling trenches.

3.9 INSTALLATION OF CONTROL SYSTEM COMPONENTS

A. Control Units:

1. Install control units at locations indicated on Drawings.
2. Install electrical connections according to manufacturer's instructions and as indicated on Drawings.
3. **Lightning Protection:** Drive full length grounding rods into soil. Provide and install grounding plates as indicated on Drawings or as required to create grounding connection with field-tested resistance value equal to or lower than specified values identified in this specification. Connect 4mm diameter (#6 AWG) copper grounding wire to rod and plate using CADWELD style connections. Brand "GR" in 50 mm (2 inch) high by 5 mm (3/16 inch) deep letters on valve box lid.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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4. Attach wire markers to control wire ends inside controller unit housing. Label remote control valve wires with identification number indicated on Drawings, where control wire is connected.
5. Connect control wire to corresponding control unit terminal.
6. Install permanent receiver for hand held radio when not factory installed.
7. Install rain sensor and complete electrical connections control unit according to manufacturer's instructions.

B. Power Wire:

1. Route power wire as indicated on Drawings. Install minimum number field splices. When power wire is spliced, make splice with recommended connector. Place splices in separate 300 mm (12 inch) standard valve box. Coil 600 mm (2 feet) wire in valve box. Brand "WS" in 50 mm (2 inch) high by 5 mm (3/16 inch) deep letters on valve box lid.
2. Lay power wire in trenches. Do not use vibratory plow.
3. Wire: NEC code compliant, green wire as common ground wire from power source to satellites and white for common (neutral) wire.
4. Carefully backfill around power wire, avoid wire insulation or wire connector damage.
5. Unless noted on Drawings, install wire parallel with and below mainline pipe. Install wire minimum 50 mm (2 inches) below bottom of PVC mainline pipe.
6. Encase wire in electrical conduit not installed with PVC mainline pipe, with continuous run of warning tape placed in backfill, 200 to 250mm (8 to 10 inches) below ground surface, directly over wiring.
7. Surface mount wire installed above grade in a professional manner, routing approved by COR.
8. Connect wire to power source.

C. Control Wire:

1. Bundle two or more control wires in the same trench. Bundle with pipe wrapping tape spaced 3 m (10-foot) intervals.

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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2. Chisel control wiring into soil utilizing vibratory plow device manufactured for pipe pulling and wire installation. Use appropriate chisel with wire, fed into chute on chisel, and not subject to pulling tension. Minimum burial depth equal minimum cover previously listed.
3. Provide 600 mm (24 inch) excess wire length in 200mm (8 inch) diameter loop at each 90 degree change in direction, at both ends of sleeves, and at 30 m (100-foot) intervals along continuous wire runs. Do not tie wiring loop. Coil 600mm (24 inch) wire length within each remote control valve box.
4. Install common ground wire and one control wire for each remote control valve. Multiple valves on single control wire are not acceptable.
5. Install spare control and common wires as indicated on Drawings.
6. Use wire connectors and waterproof sealant to splice wire according to manufacturer's instructions. Locate splices in valve box containing irrigation valve assembly, or in separate valve box. Use same procedure for valve connection and in-line splices. When separate valve box is used for wire splices, brand "WS" in 50 mm (2 inch) high by 5 mm (3/16 inch) deep letters on valve box lid.
7. Install wire parallel with and below mainline pipe, unless indicated on Drawings.
8. Protect wire not installed with PVC mainline pipe with continuous run of warning tape place in backfill 150 mm (6 inches) above wiring.
9. Cap exposed wire ends with waterproof wire splices.
10. Locate wiring in trench from master controllers to satellites and stub-cuts for future extension, with new mains or in separate trench at back of curb, unless cross-country route is indicated on Drawings. Locate in trench with mains when possible on cross-country routes.
11. Set wiring bundles located with piping, below bottom of pipe. No two wires of same colors in any bundle. Bundle and tie or taped wires at 3 m (10 foot) intervals. Provide same numbered tag at

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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each wire end, i.e., at valve, at field located controllers and at master controller.

12. Minimize splicing. Provide pull box at each splice. No splice will be allowed between field located controllers and remote control valves.
13. Provide 300 mm (12 inch) expansion loops in wiring at each wire connection or change in wire direction. Provide 600 mm (24 inch) loop at remote control valves.
14. Do not place irrigation system power wiring in same conduit as control wiring.

D. Instrumentation:

1. Install according to manufacturer's instructions at location indicated on drawings.
2. Provide electrical connections between central control system hardware and weather station under direction and observation of central control system manufacturer's personnel.

3.10 TRACER WIRE INSTALLATION

- A. Install tracer wire on trench bottom, adjacent to vertical pipe projections, continuous throughout pipe length, with spliced connections soldered and wrap with insulation tape.
- B. Install tracer wire following main line pipe and branch lines and terminate in yard box with gate valve controlling main irrigation lines. Provide sufficient wire length to reach finish grade, bend back wire end making loop and attach Dymo-Tape type plastic label with designation "Tracer Wire."
- C. Record tracer wire locations and terminations on project record documents.

3.11 INSTALLATION OF OTHER COMPONENTS

- A. Tools and Spare Parts:
 1. Before punch list review, provide operating keys, servicing tools, spare parts, and other items indicated on Drawings.
- B. Other Materials: Install other materials or equipment indicated on Drawings or installation details that are part of irrigation system.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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3.12 FIELD QUALITY CONTROL

A. Special Inspections and Tests:

1. On-Site Radio Test: Conduct on-site radio test before submitting bid for type of radio control.

B. Field Tests: Performed by testing laboratory specified in Section 01 45 29, TESTING LABORATORY SERVICES.

1. Test irrigation system per procedures listed in section 1.10.
2. Notify the COR three days in advance of testing.
3. Newly installed irrigation pipelines jointed with rubber gaskets or threaded connections shall be subject to pressure and leakage testing after partial completion of backfill. Pipelines jointed with solvent-welded PVC joints will be allowed to cure at least 24 hours before testing.
4. Subsections of mainline pipe may be tested independently, subject to the review of the COR.
5. Provide clean, clear water, pumps, labor, fittings, power and equipment necessary to conduct tests or retests.
6. Volumetric Leakage Test - Gasketed Mainline Pipe:
 - a. Backfill to prevent pipe from moving under pressure. Expose couplings and fittings.
 - b. Purge all air from the pipeline before test.
 - c. Provide all necessary pumps, bypass piping, storage tanks, meters, 75 mm (3 inch) test gauge, supply piping, and fittings in order to properly perform testing. Testing pump must provide a continuous 700 kPa (100 psi) pressure to the mainline pipe. Where main lines are installed with significant elevation change, perform the test at the mid elevation of the segment being tested. Main lines may be tested in segments where the terrain makes it difficult to maintain the test pressure throughout. The test pressure is the minimum pressure on the line at the highest point of the line segment being tested.
 - d. Allowable deviation in test pressure, 35 kPa (5 psi) during test period; average pressure during test, 700 kPa (100 psi)

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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therefore the pressure shall start at 5 psi above and be re-pressurized when the pressure is 5 psi below the test pressure. Restore test pressure to 700 kPa (100 psi) at end of test. Measure water added to mainline pipe volumetrically to nearest 10 ml (0.025 gallons).

- e. Subject mainline pipe to the anticipated operating pressure of 700 kPa (100 psi) for two hours. Amount of additional water pumped in during test not exceeding the value in table, or the calculated value using the formula below, based on differing number of joints, duration or pressure of the test:
- 1) Leakage Allowable (Gallons per (100 Joints)/Hour).

PIPE SIZE mm (INCHES)	Test Pressure (PSI)								
	60	70	80	90	100	110	120	130	140
63mm (2 1/2")	0.26	0.28	0.30	0.32	0.34	0.35	0.37	0.39	0.40
75mm (3")	0.31	0.34	0.36	0.38	0.41	0.43	0.44	0.46	0.48
100 mm (4")	0.42	0.45	0.48	0.51	0.54	0.57	0.59	0.62	0.64
150 mm (6")	0.63	0.68	0.73	0.77	0.81	0.85	0.89	0.92	0.96
200 mm (8")	0.84	0.90	0.97	1.03	1.08	1.13	1.18	1.23	1.28
250 mm (10")	1.05	1.13	1.21	1.28	1.35	1.42	1.48	1.54	1.60
300 mm (12")	1.26	1.36	1.45	1.54	1.62	1.70	1.78	1.85	1.92

Note: Allowable Leakage calculated using $L = (ND\sqrt{P})/7400$.

Where: L = Allowable Leakage (gph).

N = Number of Joints.

D = Nominal Diameter of Pipe (inches).

P = Average Test Pressure (psi).

- 2) The following are the values for a 2 hour duration test at 100 psi for pipe length containing 100 joints.

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- a) 3.10 L (0.82 gallons) per 100 joints of 75 mm (3 inch) diameter pipe.
 - b) 4.09 L (1.08 gallons) per 100 joints of 100 mm (4 inch) diameter pipe.
 - c) 6.13 L (1.62 gallons) per 100 joints of 150 mm (6 inch) diameter pipe.
 - d) 8.18 L (2.16 gallons) per 100 joints of 200 mm (8 inch) diameter pipe.
 - e) 10.22 L (2.70 gallons) per 100 joints of 250 mm (10 inch) diameter pipe.
 - f) 12.26 L (3.24 gallons) per 100 joints of 300 mm (12 inch) diameter pipe.
 - g) Volumetric leakage exceeding the amounts indicated above, adjusted for system test pressure, number of joints and shall be a failure of the test. Replace defective pipe, fitting, joint, valve, or appurtenance. Repeat the test until the pipe passes test.
- f. Cement or caulking to seal leaks is prohibited.
 - g. Contractor may sub-contract testing to pipeline testing company approved by RE/COTR.

7. Hydrostatic Pressure Test - Solvent Weld Lateral Pipe:

- a. Subject lateral pipe to a hydrostatic pressure equal to the anticipated operating pressure of 550 kPa (80 psi) for 30 minutes.
- b. Cap all sprinkler risers.
- c. Backfill to prevent pipe from moving under pressure. Expose couplings and fittings.
- d. Leakage will be detected by visual inspection. Replace defective pipe, fitting, joint, valve, or appurtenance. Repeat the test until the pipe passes test.
- e. Cement or caulking to seal leaks is prohibited.

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- f. After lateral passes test and before operational test, install sprinklers and backfill and compact all pipe, fittings, joints, or appurtenance.
8. Operational Test - Remote Control Valves, Lateral Piping and Sprinklers:
- a. Activate each remote control valve in sequence from each new satellite controller manually at the controller, automatically from the Central Computer, and via any handheld units through central controller. Manual operation on the valves from the bleed valve on the remote control valve is not an acceptable method of activation. COR will visually observe operation, water application patterns, and leakage.
 - b. Replace defective remote control valve, solenoid, wiring, or appurtenance to correct operational deficiencies.
 - c. Replace, adjust, add, or move water emission devices to correct operational or coverage deficiencies.
 - d. Replace defective pipe, fitting, joint, valve, sprinkler, or appurtenance to correct leakage problems. Cement or caulking to seal leaks is prohibited.
 - e. Repeat tests until each lateral passes all tests. Repeat tests, replace components, and correct deficiencies at no additional cost to the Owner.
 - f. Test backflow prevention device with certified tester before project acceptance.
9. Distribution Uniformity (DU):
- a. Perform DU Test on one zone of burial section rotors and one zone of tree lawn rotors per satellite controller.
 - b. Select the zones of sprinklers representative of area being irrigated by satellite controller in the presence of the COR.
 - c. Perform catch can test using procedures recommended by Irrigation Association.
 - d. Where DU test fails, adjust zone pressures and nozzle sizes to meet required Distribution Uniformity.

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- e. Calculate and provide written documentation of DU for each zone tested.
 - f. Irrigation Association Certified Landscape Irrigation Auditor must perform the test. Provide written evidence of certification before conducting test.
10. Control System Grounding:
- a. Test all new satellite controllers for proper grounding of control system with installed grounding equipment that creates grounding resistance readings of 5 ohms or less or higher levels not to exceed 15 ohms, when acceptable by equipment manufacturer without equipment warranty invalidation. Test results meet or exceed control system manufacturer's instructions for acceptance, while maintaining equipment warranty.
 - b. Replace defective wire, grounding rod or appurtenances. Repeat test until manufacturer's instructions are met. Add grounding rods as needed, bond all rods together.
 - c. When test is acceptable, document results of grounding test on inside of each satellite controller pedestal door and via written report submitted to the COR. Documentation includes satellite name or number, date of test, name or initials of the individual completing the test, and the ohms resistance to ground. Mark test results on the inside of each satellite controller pedestal door using a permanent marker.
 - d. Submit to the COR, written report of test data listing satellite name or number, date of test, name of the individual completing the test, name of the company completing the test and the ohms resistance to the local ground for each satellite.
11. Irrigation System Acceptance Test (Burn inches) before Final Inspection:
- a. Upon completion of construction and before Final Inspection, an Acceptance Test (Burn inches) must be passed.
 - b. Coordinate start of Test with COR.

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EHRM Infrastructure Upgrades-Tier 2

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- c. During Test, irrigation system must be fully operational from central control system. Operate irrigation system, with no faults for 14 consecutive days. When at any time during the 14 day test period, system fault occurs, determine source of the fault and correct, and restart 14 day evaluation period. When system fault occurs, make repairs within 24 hours of notification from COR. Document any faults of test report listing date, fault, cause of fault and corrective action taken.
 - d. When system has operated for 14 days without fault, contact the COR to schedule Final Inspection.
 - e. When system is designed to detect flow and shut down and this condition happens during test, this is considered a success and test continues; when does not shut down, test starts over.
12. Flushing: After testing, flush system beginning with larger mains and continuing through smaller mains in sequence. Flush lines before installing sprinkler heads and quick couplers.
13. Operation Test: Upon completion of the final adjustment of sprinkler heads to permanent level at ground surface, test each sprinkler section by pan test and visual test to indicate uniform distribution within any one sprinkler head area and over the entire area. Operate entire installation to demonstrate the complete and successful operation of all equipment.
- C. Maintenance Services:
- 1. Maintenance and Operating Instructions: Before final acceptance, provide verbal instructions, minimum 16 hours, to operating personnel. Provide two additional years of software support for one hour each month. Provide Maintenance and Operating Instructions for the provided irrigation system in the form of manuals as follows:
 - a. Unless otherwise noted, provide irrigation operation and maintenance information in a 3-ring binder with table of

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EHRM Infrastructure Upgrades-Tier 2

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contents and index sheet. Provide sections that are indexed and labeled. Provide the following information:

- b. Catalog cut sheets for control system, valves, sprinklers, pipe and fittings, wire and wire connectors, ID tags, shop drawings, and all other irrigation equipment shown or described on the drawings and within these specifications.
- c. Manufacturer's Operation and Maintenance manuals.
- d. Manufacturer's Technical Service Bulletins.
- e. Manufacturer's Warranty Documentation.
- f. Software License Information.
- g. Recommended routine maintenance inspections for weekly, monthly and annual inspections and recommended actions for the inspections and a recommended method for recording the findings of the inspections.
- h. Predictive schedule for component replacement.
- i. Listing of technical support contacts.

3.13 WINTERIZATION AND SPRING START-UP

- A. Winterize new irrigation system according to local practices in first fall after completion of construction of irrigation system and start up in spring after completion of construction. Repair any damage caused in improper winterization. Coordinate winterization and start-up with cemetery landscape maintenance personnel.

3.14 CLEANING

- A. Clean exposed surfaces. Remove contaminants and stains.

3.15 DEMONSTRATION AND TRAINING

- A. Instruct VA personnel in proper irrigation system operation and maintenance.
 - 1. Trainer: Manufacturer approved instructor.
 - 2. Training Time: 30 days minimum.
- B. Submit training plan and trainer qualifications.
- C. Acceptance Condition: After completing work, operate irrigation system 15 consecutive calendar days without breakdown.

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- D. Provide training video on DVD or CD, whichever is compatible with the computer system provided for the central computer, to familiarize maintenance personnel with equipment provided. Coordinate final training presentation with Architect/Engineer and COR in outline form before creation, verify format and organization of content is applicable for facility staff utilization.

3.16 PROTECTION

- A. Protect from traffic and construction operations.
- B. Cover with reinforced kraft paper, and plywood or hardboard.
- C. Remove protective materials immediately before acceptance.
- D. Repair damage.

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SECTION 32 90 00
PLANTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Plants, soils, turf, and landscape materials and accessories.

1.2 RELATED REQUIREMENTS

- A. Topsoil Materials, Stripping and Stockpiling: Section 31 20 00, EARTH MOVING.
- B. Topsoil Testing: Section 01 45 29, TESTING LABORATORY SERVICES.
- C. Erosion control: Section 01 57 19, TEMPORARY ENVIRONMENTAL CONTROLS.
- D. Protection of Tress and Plantings: Section 02 41 10, DEMOLITION AND SITE CLEARING.
- E. Topsoil Placement and Compaction Test: Section 31 20 00, EARTH MOVING.
- F. Landscape Irrigation: Section 32 84 00, PLANTING IRRIGATION.

1.3 APPLICABLE PUBLICATIONS

- A. Comply with references to extent specified in this section.
- B. American National Standards Institute (ANSI) Publications:
 1. ANSI Z60.1-2014 - Nursery Stock.
 2. ANSI Z133.1-2012 - Tree Care Operations-Pruning, Trimming, Repairing, Maintaining, and Removing Trees and Cutting Brush- Safety Requirements.
- C. ASTM International (ASTM):
 1. C33/C33M-16-Concrete Aggregates.
 2. C136/C136M-14 - Sieve Analysis of Fine and Coarse Aggregates.
 3. D698-12 - Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³)).
 4. D977-13e1 - Emulsified Asphalt.
 5. D2028/D2028M-15 - Cutback Asphalt (Rapid-Curing Type).
 6. D2103-15 - Polyethylene Film and Sheeting.
- D. Hortus Third, most current edition: A Concise Dictionary of Plants Cultivated in the United States and Canada.
- E. National Cemetery Administration (NCA):

Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft-AE Project No. 22-113

32 90 00-1

01/16/24

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EHRM Infrastructure Upgrades-Tier 2

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1. Handbook 3410 - Integrate Pest Management.
2. Handbook 3420-11 - Turfgrass Maintenance.
- F. Turfgrass Producers International (TPI):
 1. 2006 Guideline Specifications to Turfgrass Sodding.
- G. United States Department of Agriculture (USDA):
 1. Federal Seed Act-2011 - Rules and Regulations of the Secretary of Agriculture.
- H. United States Environmental Protection Agency (EPA):
 1. 40 CFR Part 503-1993 - Biosolids Rule.

1.4 PREINSTALLATION MEETINGS

- A. Conduct preinstallation meeting at project site minimum 30 days before beginning Work of this section.
 1. Required Participants:
 - a. Contracting Officer's Representative (COR).
 - b. Architect/Engineer (A/E).
 - c. Contractor.
 - d. Installer.
 2. Meeting Agenda: Distribute agenda to participants minimum 3 days before meeting.
 - a. Inspection of planting materials.
 - b. Installation schedule.
 - c. Installation sequence.
 - d. Preparatory work.
 - e. Protection before, during, and after installation.
 - f. Installation.
 - g. Inspecting.
 - h. Environmental procedures.
 3. Document and distribute meeting minutes to participants to record decisions affecting installation.

1.5 SUBMITTALS

- A. Submittal Procedures: Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's Literature and Data:

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1. Description of each product.
 - a. Seeds.
 - b. Sod.
 - c. Soil amendments.
 - d. Antidesiccant.
 - e. Erosion control materials.
 - f. Hydro mulch.
 - g. Non-Asphaltic Trackifier.
 - h. Herbicide.
 - i. Weed Control.
 - j. Mulches.
 - k. Edging.
 2. Plant list: List of local/regional suppliers for each species to be installed. Include quantities, plant dimension (height x spread) and container/root ball size. Certify in writing, confirmed orders for plants by submitting a Bill of Sale for each plant to be installed. Each plant of the same species shall be supplied by one grower only unless otherwise approved by COR.
 - a. Requests for substitutions of plants not available in size, quantity or type specified must be made within 30 days after Contract award. Submit written evidence that a specified plant cannot be obtained and has been unobtainable since Contract award.
 - b. Substitutions will only be authorized when a plant (or its alternates as specified) is not obtainable and COR, in consultation with District Agronomist, authorizes a change order for use of nearest equivalent obtainable size or variety of plant having same essential characteristics with an equitable adjustment of contract price.
 3. Warranty.
- C. Samples: Submit before beginning Work of this section:

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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Inert Mulch	2.3 kg (5 lb.) of each type to be used.
Organic Mulch	2.3 kg (5 lb.) of each type to be used.
Imported Topsoils	2.3 kg (5 lb.) of each type to be used.
Organic Amendments	2.3 kg (5 lb.) of each type to be used.
All pesticides required such as preemergence or post emergence herbicides, insecticides, or fungicides.	EPA approved labeling and MSDS sheet for each such product selected for use.
Edging Materials	Manufacturer's standard size

D. Test reports: Certify products comply with specifications.

1. Imported Topsoil: Provide 2.3 kg (5 lbs.) representative sample from each proposed source for testing, analysis, and approval. Deliver samples to acceptable testing laboratory and have testing report sent directly to COR. Testing reports to include following tests and recommendations according to Association of Official Agricultural Chemists standards:
 - a. Soil Composition: USDA particle size analysis indicating percentages of sand, silt and clay, and percent organic matter. Mechanical gradation (sieve analysis) and chemical (pH soluble salts) performed by public extension service agency, State Land Grant College, or certified private testing laboratory. Percentages of clay and silt to be determined by hydrometer.
 - b. Percent of organics to be determined by loss on ignition of oven-dried samples. Test samples to be oven-dried to constant weight at 110 degrees C (230 degrees F), plus or minus 5 degrees C (41 degrees F).

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Fargo, North Dakota 58102-2417
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- c. Macro and micro nutrient fertility tests as determined by Chemical analysis to include Macro and micro nutrient fertility tests as determined by pH, Salinity (EC), Nitrate Nitrogen, Ammonium Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Soluble Copper, Zinc, Manganese, Iron, Saturation Extract Boron, Aluminum, Soluble Salts, Exchangeable Sodium Percentage (ESP), Sodium Adsorption Ratio (SAR), and Cation Exchange Capacity (CEC).
 - d. Tests, as specified, for gradation, organics, soil chemistry and pH to be performed by testing laboratory retained by National Cemetery Administration as described in Section 01 45 29, TESTING LABORATORY SERVICES.
 - e. Include recommendations for soil additives to correct soils deficiencies, as necessary, and for fertilizing and to adjust soil pH to optimum range for warm season turfgrass liming applications to support successful turfgrass growth.
2. Organic Soil Amendment:
- a. Testing: Provide testing by an independent laboratory, with the experience and capability to conduct the testing indicated following U.S. Composting Council Seal of Testing Assurance (STA) procedures, or equivalent.
 - b. Soil Amendment Analysis: Provide documentation from supplier that compost has reached a monitored temperature of 140 degrees Fahrenheit for at least one week. Engage an independent soil testing laboratory to test representative samples of compost and provide compost analysis report for the following parameters:
 - 1) Percent organic matter, percent moisture, percent inerts (foreign matter), pH, soluble salts, and particle size.
 - 2) Nutrient content, including: Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), and Magnesium (Mg) and Sulfur s.
 - 3) Trace Metals, including: Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Mercury (Hg), Nickel (Ni), and Zinc (Zn).

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- 4) Maturity Indicator. Provide bioassay results. Provide Carbon-Nitrogen ratio.
- 5) Stability Indicator: Provide respiration test results.
3. Amended Soil (in place): Following incorporation of amendments and additives, provide minimum six (6) samples per 3,700 sq. m (40,000 sq. ft.), 150 mm (6 inch) depth by 75 mm (3 inch) diameter core samples of amended soil taken from project site for testing, analysis, and approval. Locate each samples as directed by COR from areas designated to be planted in turfgrass. Deliver samples to testing laboratories and have testing report sent directly to COR. Obtain amended soil sample acceptance before seeding or hydroseeding.
- E. Certificates: Certify products comply with specifications.
- F. Before delivery, submit notarized certificates for approval to COR attesting that following materials meet specified requirements:
 1. Plant Materials (Department of Agriculture certification by State Nursery Inspector from the state in which the plant material originates declaring material to be free from insects and disease).
 2. Fertilizers: Four certificates of analysis for each type of fertilizer.
 3. Lime.
 4. Gypsum.
 5. Soil Sulfur.
 6. Humates.
 7. Mycorrhizae.
 8. Peat.
 9. Seed: Include guaranteed percentages of purity, weed content and germination of seed, and net weight and date of shipment.
 10. Sod.
 11. Membranes.
 12. Hydro Mulching: Number of kilograms (pounds) of materials to be used per liter (gallon) of water.
- G. Maintenance Data:
 1. Care instructions for each plant material.

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1.6 QUALITY ASSURANCE

A. Installer Qualifications:

1. Regularly installs specified materials and products.
2. Installed specified products with satisfactory service on five similar installations for minimum five years.
 - a. Project Experience List: Provide contact names and addresses for completed projects.
 - b. A member with good standing of either the Professional Landcare Network (PLANET) the AmericanHort.
 - c. Maintain an experienced full-time supervisor on Project site when work is in progress.
 - d. Installer's field supervisor personnel assigned to the Work shall have certification in one of the following categories from the Professional Landcare Network and submit one copy of certificate to the COR:
 - e. Certified Landscape Technician (CLT) - Exterior, with installation, maintenance, and irrigation specialty areas, designated CLT-Exterior.
 - f. Certified Ornamental Landscape Professional designated COLP.

B. Licenses: Submit licenses to COR:

1. Arborist: One copy.
2. Pesticide Applicator: License in state of project, commercial.

1.7 DELIVERY

- A. Deliver products in manufacturer's original sealed packaging.
- B. Mark packaging, legibly. Indicate manufacturer's name or brand, type, production run number, and manufacture date.
- C. Before installation, return or dispose of products within distorted, damaged, or opened packaging.
- D. Bulk Products:
 1. Deliver bulk products away from buildings, utilities, pavement, and existing turf and planted areas. Maintain dry bulk product storage away from contaminants. Protect products from weather.

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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2. Install erosion control materials to prevent erosion or displacement of bulk products.
- E. Notify COR of delivery schedule five days in advance, minimum. COR will inspect materials upon arrival. Remove unacceptable plant materials from project site immediately.
- F. Protect plants during delivery to prevent damage to root balls or desiccation of leaves.
- G. Protect trees during transport by covering root balls and tying branches.
- H. Machine dug plants are permitted provided root balls are sized according to ANSI Z60.1 and tops are protected from damage.
- I. Protect sod from drying out.

1.8 STORAGE AND HANDLING

- A. Store seeds, soil amendments, fertilizers, and packaged materials in dry locations away from contaminants.
- B. Keep sod moist and protect from exposure to wind and direct sunlight.
- C. Store plants not installed on day of arrival at project site as follows:
 1. Shade and protect plants from wind when stored outside.
 2. Heel in bare root plants.
 3. Protect plants by covering roots with moist wood chips, shredded bark, peat moss, or similar mulching material.
 4. Keep plants moist including those in containers, by watering with fine mist spray until planted.

1.9 FIELD CONDITIONS

- A. Seasons and Conditions:

1. Perform landscape planting operations within following dates: From April 1st to July 31st for spring and from August 1st to October

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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31st for fall, but not before irrigation system installed, tested, and approved.

- B. Perform turfgrass installation operations within following dates, but not before irrigation system installed, tested, and approved.
 - 1. Spring Planting: April 1st to July 31st.
 - 2. Fall Planting: August 1st to October 31st.
- C. Restrictions: Do not plant when ground is frozen, snow covered, saturated or in otherwise unsuitable condition for planting. Special conditions may exist that warrant variance in specified planting dates or conditions. Submit written request for approval to COR stating special conditions and proposal variance.

1.10 WARRANTY

- A. Construction Warranty: FAR clause 52.246-21, "Warranty of Construction."
- B. Comply with "Warranty" requirements in Section 00 72 00, GENERAL CONDITIONS, including the following supplements:
 - 1. One Year Plant and Turfgrass Warranty: Warranty begins when Government accepts plants and turfgrass but not before end of Landscape Plant and Turfgrass Establishment Period.
 - 2. Replace any dead plant material and any areas void of turfgrass immediately during warranty period and during an active growing season. One year warranty for replaced plants and turfgrass begins on day replacement work is completed and accepted.
 - 3. Replacement of relocated plants, not furnished, is not required unless they die from improper handling and care. Loss due to improper handling, care, or negligence requires replacement in kind and size.
 - 4. Government will inspect replacement plants and turfgrass at end of Warranty period. Replace any dead, missing, or defective plant material and turfgrass immediately and during growing season. Warranty ends on date of this inspection provided work specified in this section is complied.
 - 5. Remove stakes, guys wires/straps at end of one year warranty.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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PART 2 - PRODUCTS

2.1 PRODUCTS - GENERAL

- A. Provide each product from one source or manufacturer.
- B. Plant and Turf Grasses: Comply with the varieties specified or shown in plant list.
- C. Warrant plants are true to botanical name as listed in Hortus Third.
- D. Maintain equipment, tools and machinery on project site in sufficient quantities and capacity for proper execution of Work.

2.2 ORGANIC SOIL AMENDMENT

- A. Organic Soil Amendment: Dark brown or black and capable of enhancing plant growth. Ninety-eight percent of material passes 25 mm (1 inch) screen. No admixture of refuse (i.e. noticeable inert contamination) or materials toxic to plant growth are permitted, free of all woody fibers, seeds, leaf structures, plastic, petroleum products, and toxic and non-organic matter.
 - 1. Acceptable Organic Soil Amendments: Peat moss, humus or peat, and commercially available combinations thereof.
 - 2. Acceptable Compost: Natural organic sources such as food or animal residuals, or yard trimmings.
 - 3. Unacceptable Sole Sources of Organic Matter: Untreated sludge from wastewater treatment plants, fresh manure, sawdust, and immature composts.
- B. Minimum Material Requirements:

Test Parameter	Acceptable Ranges
Organic Matter	27 to 80 percent
pH	5.5 to 8.5
Ash	20 to 65 percent
Nitrogen	0.4 to 3.5 percent
Phosphorus	0.2 to 1.5 percent
Potassium	0.4 to 1.5 percent
C: N Ratio	25 to 30: 1

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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Test Parameter	Acceptable Ranges
CEC	50 to 150 meq/100 g
Heavy Metals	Less than max. limits established by EPA 40 CFR Part 503
Inert Contents	Less than 1 percent by weight
Water-Holding Capacity	150 to 200 percent
Pathogen/Weed Seed Destruction	Proof of EPA minimum heating requirements

- C. Topsoil stripped and stockpiled on project site is acceptable provided, after testing and addition of necessary additives, meets above specification. Provide additional Organic Soil Amendment as required to complete work.
- D. Provide organic soil amendment in areas with organic matter content below 4 percent that will be seeded, sodded or sprigged after grading activities are completed to create satisfactory topsoil horizon.
- E. Spread and incorporate organic soil amendment into finished subgrade at depths indicated on drawings to raise soil organic content to minimum four percent and maximum six percent. Allow for additional depth of organic soil amendment to bring all grades to required finished grades as shown on grading plans.

2.3 PLANTS

- A. Plants: ANSI Z60.1, except as otherwise stated in this section or shown on drawings. Where drawings or specifications are in conflict with ANSI Z60.1, drawings and specification will prevail.
 - 1. Provide well-branched and formed planting stock, sound, vigorous, and free of disease, sunscald, windburn, abrasion, harmful insects or insect eggs with healthy, normal, and unbroken root systems.
 - 2. Provide single stemmed trees, with a single leader, unless otherwise indicated.
 - 3. Provide trees and shrubs of uniform, symmetrical growth, with straight boles or stems, free from objectionable disfigurements, and with branch spread of branches typical of variety.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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4. Provide ground cover and vine plants with number and length of runners for size, and proper age for grade of plants specified. Provide well established plants in removable containers, integral containers, or formed homogeneous soil sections.
 5. Provide plants grown under climatic conditions similar to those in project locality.
- B. Minimum acceptable sizes of all plants, measured with branches in normal position, to conform to plant list and ANSI Z60.1. Larger plants with COR's approval, at no additional cost to the Government. Increase ball of earth or spread of roots according to ANSI Z60.1 when larger plants are provided.
 - C. Do not handle plants by trunk or stem. Trees must be moved by lifting root ball, box or container.
 - D. Bare-root (BR) plants to have root system substantially intact, but with earth carefully removed. Cover roots with thick coating of mud by "puddling" after the plants are dug.
 - E. Container grown plants to have sufficient root growth to hold earth intact when removed from containers, but not be root bound.
 - F. When existing plants are to be relocated, ball sizes to conform to ANSI Z60.1 requirements for collected plants, with plants dug, handled, and replanted according to applicable requirements of this section.

2.4 LABELS

- A. Legibly tag each plant, or group and bundles or containers of the species, variety, and size of plant with durable, waterproof and weather-resistant label indicating correct plant name and size specified in plant list. Labels to be securely attached and not removed until acceptance by the Government.

2.5 TOPSOIL

- A. Topsoil: Provide well-graded soil of good uniform quality, natural, friable soil representative of productive soils in project vicinity. Topsoil to be free of subsoil, foreign matter, objects larger than 25 mm (1 inch) in any dimension, toxic substances, weeds and any material or substances that may be harmful to plant growth and have pH

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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value of minimum 6.0 and maximum 7.0, and be best suited to region, climate and plant material specific to project.

- B. Obtain material from stockpiles established under Section 31 20 00, EARTH MOVING, subparagraph, Stripping Topsoil that meet general requirements stated above. Amend topsoil not meeting pH range specified by the addition of pH adjusters.
- C. When sufficient topsoil is not available on project site to specified depth, provide additional topsoil. Minimum 10 days before topsoil delivery, notify COR of sources from which topsoil will be furnished. Obtain topsoil meeting general requirements stated above and comply with requirements specified in Section 01 45 29, TESTING LABORATORY SERVICES. Amend topsoil not meeting pH range specified by adding pH adjusters.

2.6 INORGANIC SOIL AMENDMENTS

- A. Lime: Agricultural limestone, minimum 90 percent calcium and magnesium carbonates. Grind lime fineness, minimum 90 percent passes No. 8 mesh and minimum 25 percent passes No. 100 mesh. Maximum moisture, 10 percent.
 - 1. Dolomitic Lime: Natural, agricultural limestone (calcium and magnesium carbonate), minimum of 20 percent calcium and 11 percent magnesium and as follows:
 - a. Screen Analysis: 100 percent passing through No.30 sieve; 70 percent passing through No. 100 sieve; minimum 30 percent passing through No.325 sieve. Provide lime in form of granulated, prilled, dolomitic limestone.
 - 2. Calcitic Lime: Natural, agricultural limestone (calcium carbonate), minimum of 36 percent calcium and as follows:
 - a. Screen Analysis: minimum of 100 percent passing through No. 10 sieve; minimum of 80 percent passing through No. 100 sieve. Provide lime in form of granulated, prilled, limestone.
 - 3. Agricultural Gypsum: Finely ground, minimum of 90 percent calcium sulfate, or 85 percent calcium sulfate dihydrate.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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4. Sulfur: Granular, biodegradable, minimum of 90 percent sulfur, with a minimum of 99 percent passing through No. 6 sieve and a maximum of 10 percent passing through No. 40 sieve.
5. Iron Sulfate: Granulated ferrous sulfate minimum of 20 percent iron and 10 percent sulfur.
6. Aluminum Sulfate: Commercial grade, unadulterated.
7. Sand: Clean washed river sand, free of calcium, chlorides and other deleterious substances.
8. Humates: Derived from mined Gypsum and with guaranteed minimum analysis; Calcium Sulfate dihydrate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) 35.00%; Calcium (Ca) 7.00%; Sulfur s 5.00%, plus Humic Acids 1.5% derived from Leonardite. Pelletized product used for ease of application..
9. Mycorrhizae: Endomycorrhizal powder inoculum consisting of the following 4 species blend of propagules of arbuscular mycorrhizal fungi: Glomus intraradices, Glomus mosseae, Glomus aggregatum, and Glomus etunicatum. Minimum 100,000 spores/propagules per pound. The powder particle size shall be less than 300 microns (100 percent passing the #50 screen).

2.7 ORGANIC SOIL AMENDMENTS

- A. Peat: Natural product of sphagnum moss peat, peat moss, hypnum moss, peat reed-sedge peat, or peat humus derived from fresh-water site conforming to Fed. Spec. Q-P-166, except as otherwise specified. Shred and granulate peat to pass 13 mm (1/2 inch) mesh screen and condition in storage piles for minimum six months after excavation.
- B. Perlite: Horticulture grade.
- C. Vermiculite: Horticultural grade, free of any toxic materials.
- D. Organic Matter: Commercially prepared compost, composted sufficiently to be free of all woody fibers, seeds, and leaf structures, and free of toxic and nonorganic matter.

2.8 PLANTING SOIL MIXTURE

- A. Ornamental Plantings: Planting soil mixture composed of 3 parts topsoil and 1 part peat moss or compost.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- B. Native Plantings: 100 percent native on-site soil free of clods and subsoil. Do not amend soils intended for native planting.

2.9 PLANT FERTILIZERS

- A. Provide commercial grade plant fertilizer of uniform composition and complying with applicable state and federal regulations.
- B. For new plant material, provide uniform free-flowing granular complete analysis fertilizer based on recommendations of soils reports, containing minimum 10 percent nitrogen, phosphoric acid and potash by weight with minimum 50 percent of nitrogen from controlled release source such as sulfur coated urea (SCU), polymer coated urea (PCU), and sulfur-coated/polymer coated urea (PCSCU).
- C. For existing trees, provide a uniform free-flowing granular fertilizer bearing manufacturer's warranted statement of analysis. Granular fertilizer to contain minimum 10 percent nitrogen by weight (50 percent from controlled release source such as sulfur coated urea), 10 percent available phosphoric acid, and 10 percent potash.

2.10 TURFGRASS FERTILIZER

- A. Provide commercial grade granular fertilizer, free flowing, uniform in composition, and complying with applicable state and federal regulations. Submit fertilizer manufacturer's warranted statement of analysis. Fertilizer contain minimum 20 percent nitrogen by weight (50 percent from controlled release source such as sulfur coated urea), 5 percent available phosphoric acid, and 15 percent potash. Liquid starter fertilizer for hydro mulch slurry, commercial type with 50 percent of nitrogen from controlled release source.

2.11 MEMBRANES

- A. Polyethylene: Comply with ASTM D2103, 0.1 mm (4 mils) thick, and clear in color.
- B. Fiberglass Mat: Lime borosilicate glass fibers with 0.3 mm (0.01 inch) average fiber diameter and 50 to 100 mm (2 to 4 inch) strands of fiber bonded with phenol formaldehyde resin. Provide 100 percent textile glass fiber mat. Mat to be roll type, water permeable, and minimum 6 mm

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

(1/4 inch) and maximum 13 mm (1/2 inch) thick with 12 kg/cu. m (3/4 lb. per cu. ft.) minimum density.

- C. Landscape Fabric: Woven needle-punched polypropylene weighing 113 g/sq. m (4.8 oz./sq. yd.) with 950 liter per minute flow rate per sq. m (90 gal. per minute flow rate per sq. ft.).

2.12 MULCH

- A. Mulch: Free of deleterious materials and stored to prevent inclusion of foreign material.
- B. Mineral Mulch: Riverbank stone, granite chips, marble chips, volcanic rock or similar and ranging from 25 mm (1 inch) to 65 mm (2-1/2 inches) according to ASTM C 136.
- C. Organic Mulch: Wood based products such as chips, nuggets or shredded hardwood:
1. Straw for turfgrass seedbed mulch: Stalks from oats, wheat, rye, barley, or rice free of noxious weeds, mold or other objectionable material. Straw to be air-dried and suitable for placing with blower equipment.
 2. Wood cellulose fiber mulch for hydraulic application (Hydro mulch) with fertilizer: Specially prepared wood cellulose fiber, processed with no growth or germination-inhibiting factors, and dyed an appropriate color to facilitate visual metering of application of materials. Do not apply any turfgrass seed in this type mixture. Maximum 12 percent moisture dry weight, plus or minus three percent at time of manufacture. pH range from 3.5 to 5.0. Manufacture wood cellulose fiber for application as follows:
 - a. After addition and agitation in slurry tanks with fertilizers, water, and other approved additives, fibers will become uniformly suspended to form a homogenous slurry.
 - b. When hydraulically sprayed, material will form blotter-like cover.
 - c. Cover allows absorption of moisture and allow rainfall or applied water to percolate to underlying soil.
- D. Non-Asphaltic Tackifier:

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

1. M-Binder: 100 percent organic, non-toxic, biodegradable, free of plant-growth or germination inhibitors; a botanical glue used in hydroseeding, to stabilize soils and for dust control. Derived from the seed of the plantago plant (*Plantago insularis*). Protein content: 1.62; Ash content: 2.70; Fiber: 4.00; ph: 6.8; Settleable solids: 5.00.

2.13 EROSION CONTROL

- A. Erosion Control Net: Standard weave burlap weighing 100 to 142 g/m (3.5 to 5.0 oz./yd.). Install erosion control net according to manufacturer's instructions.

2.14 STAKES AND GUYING STRAPS

- A. Tree Support Stakes: Rough sawn wood, free of knots, rot, cross grain, or other defects that impair strength. Minimum 50 mm (2 inches) square by 2400 mm (8 feet) long and pointed at one end or galvanized steel pipe 32 mm (1-1/4 inches) by 3000 mm (10 feet) with cap, primed with 2 coats flat black exterior enamel.
- B. Hose Chafing Guards: New or used 2-ply reinforced rubber or plastic hose, all same color.
- C. Flags: White surveyor's plastic tape, 150 mm (6 inches) long, fastened to guying wires or cables.
- D. Guying Straps: Fabric designed specifically to guy newly planted trees. Wire will not be permitted.
- E. Turnbuckles: Galvanized or cadmium-plated steel with minimum 75 mm (3 inch) long openings fitted with screw eyes.
- F. Eye Bolts: Galvanized or cadmium plated steel with 50 mm (1 inch) diameter eye and minimum 40 mm (1-1/2 inches) screw length.
- G. Deadmen: 100 mm by 200 mm (4 inch by 8 inch) rectangular, or 200 mm (8 inch) diameter by 900 mm (36 inch) long sound wood.
- H. Anchors: Arrow shaped or auger iron anchors, noncorrosive, sized according to manufacturer's instructions.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

2.15 EDGING

- A. Machine Cut Divot Edge: 'V'-shaped trench used as separation between lawn and mulched planting beds. Fill machine cut divot edge with planting bed mulch as detailed in the drawings.

2.16 WATER

- A. Water: Contains no elements toxic to plant life, as specified in Section 01 00 01, GENERAL REQUIREMENTS, Paragraph, Temporary Services.

2.17 ANTIDESICCANT

- A. Antidesiccant: Emulsion manufactured for agricultural use to provide protective film over plant surfaces permeable enough to permit transpiration.

2.18 SEED

- A. Seed: State-certified seed of latest season's crop delivered in original sealed packages, bearing producer's warranted analysis for percentages of mixtures, purity, germination, weed seed content, and inert material. Label complying with USDA Federal Seed Act and applicable state seed laws. Wet, moldy, or otherwise damaged seed will not be acceptable. Onsite seed mixing will only be acceptable in presence of COR. Apply turfgrass seed separate from and before mulch material application.
- B. Minimum Acceptable Seed Quality Standards: Purity 95 percent, Germination 85 percent, Weed Seed Content less than 0.5 percent, Noxious Weeds 0.0 percent, Inert Material less than 3 percent, Germination Test Date no older than 6 months.
- C. All turfgrass seed mixtures, or sod composition to conform to species and cultivar requirements shown on plans Seed mixtures listed below are representative of an almost endless list of acceptable seed mixtures that roughly approximate these guidelines.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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Cool Season Turfgrass Seed Mixtures	Percent by Weight
Primary Mixture	50 percent perennial rye grass, 30 percent Ky bluegrass, 20 percent fine fescue
Seeding Rate	2.7 kg/90 sq. m (6 lbs./1000 sq. ft.)
Secondary Mixture	50 percent tall fescue and 50 percent perennial rye grass
Seeding Rate	4.5 kg/90 sq. m (10 lbs./1000 sq. ft.)

1. Blend each species component with minimum two regionally adapted cultivars.

Warm Season Turfgrass Seed Mixtures	Percent by Weight
Preferred Mixture, Sunny Locations	Hybrid bermudagrass cultivars available as seed. Use blend that contains minimum two of the following cultivars in approximately equal proportions - Sunsport, Princess, Riviera, Southern Star, Blackjack, Savannah, Primo Blend.
Seeding Rate	0.9 kg/90 sq. m (2 lbs./1000 sq. ft.)
Preferred Species, Shady Locations	St. Augustinegrass - sod only
Secondary Species, Low Visibility Areas	centipedegrass or bahiagrass
Seeding Rate	3.6 kg/90 sq. m (8 lbs./1000 sq. ft.)

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- D. Obtain approval of COR and NCA District Agronomist for deviations from these turfgrass species requirements.

2.19 SOD

- A. Sod: Nursery grown, certified sod as classified in TPI "Guideline Specifications to Turfgrass Sodding." Sod must also conform to turfgrass species limitations as outlined in seeding mixtures above.

2.20 HERBICIDES AND OTHER PESTICIDES

- A. Properly label and register pesticides with U.S. Environmental Protection Agency. Keep all pesticides in original labeled containers indicating analysis and method of use.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Examine and verify substrate suitability for product installation.
- B. Protect existing construction and completed work from damage.
- C. Examine areas to receive planting for compliance with requirements and other conditions affecting performance.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.
- E. Stake plant material locations and bed outlines for COR's approval before any plant pits or beds are dug. COR may make adjustments to plant material locations to meet field conditions.
- F. Identify and review all underground utility locations before commencing work and exercise caution when working close to utilities. Notify COR of apparent conflicts with construction and utilities to plan adjustment before installation.

3.2 FINE GRADING AND ORGANIC AND INORGANIC SOIL AMENDMENT INCORPORATION

- A. Obtain COR's written approval of previously completed rough grading work before incorporating organic soil amendments.
- B. Immediately before dumping and spreading approved organic soil amendment, clean subgrade of stones larger than 50 mm (2 inches) and debris or rubbish and remove from project site. Before spreading organic soil amendment, rip subgrades too compact to drain water or

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

based upon compaction tests with claw 305 mm (12 inches) deep, pulled by bulldozer 610 mm (24 inches') on center, both directions, then regrade surface.

- C. Place and uniformly spread soil amendment materials humates and mycorrhizae over approved sub-grades. Apply inorganic soil amendments as recommended by soils report. Apply organic amendments to depth sufficiently greater than specified depth so after natural settlement and light rolling, specified minimum settled depth conform to lines, grades and elevations indicated on drawings. Incorporate soil amendment by disc harrowing, rototilling or other means in uniform manner. Incorporate upon organic matter deep enough to produce finished soil with organic matter content of between 4 and 6 percent. Provide additional organic soil amendment material, after in-place testing and approval, as required for organic matter content and finished grades at no additional cost to Government.
- D. Spread organic soil amendment material minimum 100 mm (4 inches) deep to finished grade at disturbed areas outside project limits.
- E. Do not handle subsoil or organic soil amendment material when wet or frozen.
- F. Set sufficient number of grade stakes to check finished grades. Set stakes in bottom of swales and at top of slopes. Connect contours and spot elevations with even slope.
- G. After incorporating soil amendments material into subsoil, prepare by scarifying or harrowing and hand raking. Remove large stiff clods, lumps, brush, roots, stumps, litter and other foreign matter. Remove stones over 38 mm (1-1/2 inch) diameter from amended soil bed. Amended soil also to be free of smaller stones in excessive quantities as determined by COR.

3.3 EXCAVATION FOR PLANTING

- A. Compact whole surface with roller or by other suitable means to achieve 88 to 85 percent maximum dry density according to ASTM D698. During compaction process, fill all depressions caused by settling or rolling with additional organic soil amendment. Regrade and roll surface until

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

presenting smooth and even finish corresponding to required grades. Acceptable finished soil grade condition for all new turfgrass areas is "fine textured and firm." Satisfactory firmness test requires surface soil not be fluffy or powdery and able to support weight of average adult person without creating visible depression.

- B. Verify location of underground utilities before plant pit or bed excavation. Repair damaged utility lines. Where lawns have been established before planting, cover and protect before beginning excavations. Protect existing trees, shrubbery, and beds with barricades during project construction.
- C. Remove rocks and other underground obstructions to depth necessary to permit proper planting according to Drawings. Where underground utilities, construction, or solid rock ledges are encountered, COR may select other locations for plant material.
- D. Dig plant pits by approved method to provide vertical sides and flat bottoms. When sides of pit become glazed, scarify glazed surface.
- E. Where ground cover and planting beds occur in existing turfgrass areas, remove turfgrass to depth that will ensure removal of entire root system. Prepare bed as follows:
 - 1. Where existing soil is to be used in place, till beds 150mm (6 inches) deep. Spread soil amendment uniformly over bed 50 mm (2 inches) deep and thoroughly incorporate into existing soil 150mm (6 inches) deep using a roto-tiller or similar equipment to obtain uniform and well pulverized soil mix. Where existing soil is compacted (former roadways, parking lots, etc.) till soil to necessary depth to support growth of new planting. Remove all sticks, stones, roots, and other objectionable materials. Bring plant beds to smooth and even surface to comply with established grades.
- F. In newly grading areas where existing soil will be removed and replaced to prepare new planting beds, remove 150mm (6 inches) of existing soil and replace with topsoil. Bring plant beds to smooth and even surface to comply with established grades. Till 50 mm (2 inches) of soil amendment into topsoil as specified.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- G. Form earth saucers around plants with topsoil. Provide 50 mm (2 inch) high basins for shrubs and 100 mm (4 inch) high basins for trees.
- H. Treat plant saucers, shrub, and ground cover bed areas, before mulching, with approved preemergence granular ornamental herbicide. Apply herbicide at 90 kg/hectare (200 lbs./acre) before both early spring and early fall weed seed germination. Plant ground cover in areas to receive erosion control material through that material after material is in place.

3.4 SETTING PLANTS

- A. Move balled and burlapped and container-grown plants only by supporting ball or container. Remove container, taking care to prevent damage to plants or root system. Set plants plumb and hold in position until sufficient soil has been firmly placed around roots or ball. Set plants with root crown 25 mm (1 inch) above surrounding grade. Plant ground cover plants after mulch is in place. Avoid contaminating mulch with planting soil.
- B. Backfill balled and burlapped and container-grown plants with native soil removed from planting hole to approximately half ball depth, then tamp and water. Use native soil to backfill hole. Carefully fold back top half of burlap and remove tying materials. Completely remove all wire caging or similar material. Where plastic wrap or treated burlap is used in lieu of burlap, completely remove these materials before backfilling. Tamp and water remainder of backfill, then form earth saucers or water basins around isolated plants with topsoil.
- C. Plant bare-rootstock arranging roots in natural position. Form hill or mound in center of planting hole to allow plant to sit at proper depth. Spread roots out, over, and down mound in natural position. Mound to be firm to avoid settlement of entire plant. Remove damaged roots with clean cut. Carefully work native soil in among roots. Tamp and water remainder of native soil, then form earth saucers or water basins around isolated plants with topsoil.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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3.5 EDGING PLANT BEDS

- A. Uniformly edge beds using machine to provide clear cut "V"-shaped trench between planted area and adjacent turfgrass. Fill trench with mulch.

3.6 MULCHING PLANTS

- A. Apply approved preemergence granular ornamental herbicide and mulch within 48 hours after planting. Apply before both early spring and early fall weed seed germination.
- B. Placing Inert Material: Place landscape fabric with edges lapped 150 to 300 mm (6 to 12 inches) to receive inert mulch material. Punch 6 mm (1/4 inch) grid drainage holes in landscape fabric 300 mm (one foot) on centers over entire area. Spread inert mulch to uniform thickness over membrane as indicated on drawings.
- C. Placing Organic Material: Spread wood-base mulch to uniform 50 to 75 mm (2 to 3 inch) thickness. Rake smooth. Flush mulch with adjacent lawn, curbs and paving. Taper mulch thickness 50mm (2 inches) where planting beds meet adjacent areas.
- D. Keep mulch out of shrub crowns, away from tree trunks, and off buildings, sidewalks, light standards, and other structures.

3.7 PRUNING

- A. Do not prune new plants unless otherwise directed by arborist and approved by the COR. Prune indicated existing plant material as follows:
 - 1. Remove dead, broken and crossing branches.
 - 2. Make cuts with sharp instruments as close as possible to branch collar. Do not make flush cuts.
 - 3. Do not make "Headback" cuts at right angles to line of growth. Do not pole trees or remove leader.
 - 4. Remove trimmings from project site.
 - 5. Do not apply tree wound dressing to cuts.
- B. Prune existing trees as indicated on Drawings. Perform tree pruning and cavity work by licensed arborist according to ANSI Z133.1. Remove 13 mm (1/2 inch) diameter or larger dead wood, branches interfering with or

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

hindering healthy growth of trees, and diseased branches with clean cut made flush with branch collar. Prune trees according to their natural growth characteristics leaving trees well shaped and balanced. Use of climbing spurs is not acceptable. Remove stubs or limbs improper cuts or breaks.

3.8 FERTILIZATION OF EXISTING TREES

- A. Apply fertilizer to existing trees shown on drawings at rate recommended by soil test. Apply in 300 mm to 450 mm (4 inch to 8 inch) deep holes 40 to 50 mm (1-1/2 to 2 inches) in diameter, made by an earth auger, distributed evenly at maximum 600 mm (2 feet) on center throughout outer half of branch spread zone of each tree. Fertilize to within 100 mm (4 inches) of surrounding grade. Use topsoil to bring surface up to surrounding grade. When using fertilizer in packet, tablet, or wedge form, apply according to manufacturer's instructions.

3.9 TILLAGE FOR LAWN AREAS

- A. Thoroughly rip subgrades minimum 150 mm (6 inches) deep by scarifying, disking, harrowing, or other approved methods. Remove debris and stones on surface larger than 25 mm (1 inch) on surface after tillage. Do not till areas of 3: 1 slope ratio or greater. Scarify these areas to 50 mm (1 inch) depth and remove debris and stones.

3.10 FINISH GRADING

- A. After ripping subgrade for topsoil/subsoil bonding, spread topsoil evenly to minimum 150 mm (6 inches) deep. Incorporate topsoil at least 50 to 75 mm (2 to 3 inches) into subsoil to avoid soil layering. Spread additional topsoil as required to meet finish grades. Do not spread topsoil when frozen or excessively wet or dry. Correct irregularities in finished surfaces to eliminate depressions. Protect finished lawn areas from damage by vehicular or pedestrian traffic. Complete lawn work only after areas are brought to finished grade.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

3.11 APPLICATION OF FERTILIZER AND SOIL AMENDMENTS FOR TURFGRASS AREAS

- A. Apply turfgrass fertilizer and adjust soil acidity as recommended by soil test results. Add soil conditioners as specified for suitable topsoil in PART 2.
- B. Spread soil amendments as recommended by soil test results.
- C. Incorporate soil amendments into soil to minimum depth as recommended by soil test results in finish grading operation. Lightly mix starter fertilizer with top 13 mm (1/2 inch) of soil. Immediately restore soil an even condition before seeding or sod placement.

3.12 MECHANICAL SEEDING

- A. Broadcast seed with approved equipment rate as outlined in "Seed" article above. Plant turfgrass seed before application of mulch material. Uniformly distribute seed in 2 directions at right angles to each other. Drag seeded area using approved device.
- B. Immediately after dragging, firm entire area with roller maximum 225 kg/m (150 lbs./ft.) of roller width.
- C. Immediately after preparing seeded area, evenly spread straw mulch at 0.5 kg/sq. m (2 tons/acre). Anchor mulch by mulch tiller, non-asphaltic tackifier, twine, or netting.

3.13 HYDRO-MULCHING

- A. Hydro-Mulching: Mix slow release starter fertilizer and approved wood cellulose mulch material, and tackifier in required amount of water to produce homogenous slurry. Uniformly apply slurry under pressure to deliver recommended quantity of fertilizer per 100 sq. m (1000 sq. ft.).

3.14 SODDING

- A. Place sod according to TPI Guideline Specifications for sodding. Lay sod at right angles to slope or the flow of water. On slope areas, start at bottom of slope.
- B. Finishing: After sodding, blend edges of sod smoothly into surrounding area. Roll with lightweight roller to eliminate air spaces between sod and firmed soil.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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3.15 WATERING

- A. Watering: Start watering turfgrass areas immediately after installation at sufficient rate to ensure thorough wetting of soil to minimum 50 mm (2 inches) deep. Supervise watering operation to prevent run-off. Supply necessary pumps, hoses, pipelines, and sprinkling equipment. Repair all areas damaged by water operations. Keep soil surface constantly moist, not wet, until turfgrass plants are well established.
- B. Deep water all trees twice each week during Plant Establishment Period, providing water penetration throughout root zone to full depth of planting pits, as verified by COR. Discontinue watering at first hard frost in fall and resume at ground thaw in spring.

3.16 EROSION CONTROL MATERIAL

- A. Install and maintain erosion control material on designated areas as shown on drawings. Prepare, fertilize and vegetate areas to be covered, before erosion material is placed. Immediately following planting operations, lay erosion control material evenly and smoothly and in contact with soil throughout. Omit straw mulch from all seeded areas receiving erosion control material.
- B. For waterways, unroll erosion control material in direction of water flow. When two or more strips are required to cover ditch area, overlap strips minimum 100 mm (4 inches). For strips to be spliced lengthwise, overlap ends minimum 150 mm (6 inches) with upgrade section on top.
- C. On slopes, place erosion control material either horizontally or vertically to slope with edges and ends of adjacent strips butted tightly against each other.
- D. Staple each erosion control strip in three rows (each edge and center with center row alternately spaced) with staples spaced maximum 1200 mm (4 feet) longitudinally. For two or more strips side by side on slopes, install common row of staples on adjoining strips. Staple all end strips at 300 mm (12 inch) intervals at end. Firmly embed staples in underlying soil.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- E. Provide erosion control maintenance to repair damage by erosion, wind, or any other cause. Maintain, protect, repair, or replace erosion control material until Termination of the Plant and Warranty Period.

3.17 LANDSCAPE PLANT AND TURFGRASS ESTABLISHMENT PERIOD

- A. Landscape Plant and Turfgrass Establishment Period: Begins immediately after installation, with COR's approval, and continues through growing season sufficiently long for turfgrass and landscape plant materials to become establish and provide satisfactory to District Agronomist and NCA. Conditions and appearance are as follows:
1. Turfgrass has obtained minimum of 98 percent generally weed-free surface cover.
 2. Landscape Plant Materials are fully rooted, actively growing and healthy and planting beds generally weed-free.
 3. Maintain plant and turfgrass during establishment period.
 4. Plants and turfgrass will not be accepted until completion of acceptable establishment period.
 5. During Landscape Plant and Turfgrass Establishment Period complete the following:
 - a. Water plants and turfgrass to maintain moist soil surface until plants and turfgrass are well established. Quantity of applied water required to achieve and maintain these conditions determined on site by District Agronomist in consultation with COR.
 - b. Prune plants and replace mulch as required.
 - c. Replace and restore stakes, guy straps, and eroded plant saucers as required.
 - d. Remove grass, weeds, and other undesired vegetation, including root growth, before they reach 75 mm (3 inches) high in plant bed and saucers. After all unwanted vegetation has been removed, apply approved preemergence herbicides and remulch.
 - e. Spray with approved insecticides and fungicides to control pests and ensure plant survival in healthy growing condition, as directed by COR in coordination with District Agronomist.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- f. Provide the following during turfgrass establishment:
 - 1) Eradicate weeds. Water, fertilize, overseed, and perform other operation necessary to promote growth of turfgrass.
 - 2) Mow turfgrasses as often as necessary to maintain NCA specified mowing height for each type of turfgrass before final acceptance. Begin mowing when cool season turfgrass is 100 mm (4 inches) high. For warm season turfgrasses, mow at appropriate heights for species and cultivar as directed by COR in consultation with District Agronomist.
- g. Replace dead, missing or defective plant material during establishment period and an active growing season. Immediately replace each plant with one of same size and species.
- h. Replant areas void of turfgrass during an active growing season only.
- i. Sod will be evaluated for species and health thirty (30) days after laying last piece and reevaluated each 15 days during the establishment period. A satisfactory stand of grass plants from sod operation will be living sod, uniform in color and leaf texture. Bare spots to be maximum 1250 sq. mm (2 sq. inches). Joints between sod pieces to be tight and free of weeds and other undesirable growth.
- j. Seeding will be evaluated for species and health thirty (30) days after final planting and reevaluated each 15 days during the establishment period. A satisfactory stand of grass plants from seeding operation will be 98 percent coverage uniform in color and leaf texture. Bare spots to be maximum 1250 sq. mm (2 sq. inches). Reseed unsatisfactory areas within seven days during an active growing season.
- k. Complete remedial measures as directed by COR in consultation with District Agronomist to ensure plant and turfgrass survival.
- l. Repair damage caused while making plant or turfgrass replacements.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

3.18 LANDSCAPE PLANT AND TURFGRASS ACCEPTANCE

- A. Landscape plant and turfgrass acceptance will occur after completion of LANDSCAPE PLANT AND TURFGRASS ESTABLISHMENT PERIOD. Contractor to have completed, located, and installed all plants and turfgrass according to drawings and specifications. All plants and turfgrass are expected to be living and in healthy condition at time of inspection and acceptance. Make written request two weeks before final inspection of landscape plants and turfgrass. Upon inspection, when work is found to not meet specifications, PLANT AND TURFGRASS ESTABLISHMENT PERIOD will be extended at no additional cost to Government until work has been satisfactorily completed, inspected and accepted.
- B. Criteria for Acceptance of Landscape Plants:
 - 1. Planter beds and earth mound water basins are properly mulched and free of weeds.
 - 2. Total plants on site as required by specifications and required replacements have been installed.
 - 3. Remedial measures directed by COR have been completed.
- C. Criteria for Acceptance of Turfgrass:
 - 1. Sod: Living sod grass plants uniform in color and leaf texture and well rooted into soil below so that gentle pulling of turfgrass leaves by hand does not dislodge sod. Bare spots to be maximum 1250 sq. mm (2 sq. inches). Joints between sod pieces shall be tight and free from weeds and other undesirable growth.
 - 2. Seed: Living turfgrass plants with 98 percent coverage, uniform in color and leaf texture. Bare spots to be maximum 0.05 sq. m (0.5 sq. ft.).

3.19 CLEANING

- A. Remove and legally dispose of all debris, rubbish, and excess material from project site.
- B. Where existing or new turfgrass areas have been damaged or scarred, restore disturbed areas to original condition.
- C. In areas where planting and turfgrass work have been completed, clear the area of all debris, spoil piles, and containers.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- D. Maintain minimum one paved pedestrian access route and one paved vehicular access route to each building clean at all times.
- E. Clear other paved areas when work in adjacent areas are completed.

3.20 PROTECTION

- A. Protect plants and turfgrass areas from traffic and construction operations. Erect barricades, as required, and place approved signs at appropriate intervals until final acceptance.
- B. Remove protective materials immediately before acceptance.
- C. Repair damage.

3.21 ENVIRONMENTAL PROTECTION

- A. All work and operations to comply with requirements of Section 01 57 19, TEMPORARY ENVIRONMENTAL CONTROLS.

- - - E N D - - -

DIVISION 33

Utilities

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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SECTION 33 10 00
WATER UTILITIES

~~PART 1 - GENERAL~~

~~1.1 DESCRIPTION~~

~~A. Underground water distribution system complete, ready for operation, including all appurtenant structures, and connections to both new building service lines and to existing potable water supply.~~

~~B. Definitions:~~

- ~~1. Water Distribution: Pipelines and appurtenances which are part of the distribution system. The distribution system comprises the network of piping located throughout the site, as applicable, and in the building areas that provides water from the potable water supply source for the project, including hydrants, valves, and other appurtenances used to supply water for domestic, and fire-fighting/fire protection purposes only when required due to Life Safety issues.~~
- ~~2. Water Service Line: Pipe line connecting building piping to water distribution lines.~~

~~1.2 RELATED WORK~~

- ~~A. Section 01 00 02, GENERAL REQUIREMENTS (Minor NCA Projects).~~
- ~~B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.~~
- ~~C. Section 01 42 19, REFERENCE STANDARDS.~~
- ~~D. Section 01 57 19, TEMPORARY ENVIRONMENTAL CONTROLS. Erosion and Sediment Control.~~
- ~~E. Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.~~
- ~~F. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS.~~
- ~~G. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.~~
- ~~H. Section 03 30 53, (SHORT-FORM) CAST-IN-PLACE CONCRETE.~~
- ~~I. Section 09 91 00, PAINTING.~~
- ~~J. Section 21 12 00, FIRE-SUPPRESSION STANDPIPES.~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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~~K. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING: Building Plumbing starting 1500 mm (5 feet) outside of the building.~~

~~L. Section 31 20 00, EARTH MOVING: Excavation, trench widths, pipe bedding, backfill, shoring, sheeting, bracing.~~

~~M. Section 32 30 00, SITE FURNISHINGS: Flower Watering Spigot Assemblies.~~

1.3 APPLICABLE PUBLICATIONS

~~A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.~~

~~B. American Society of Mechanical Engineers (ASME):~~

~~A112.6.3-2016.....Floor and Trench Drains~~

~~B16.1-2010.....Gray Iron Pipe Flanges and Flanged Fittings,
Classes 25, 125 and 250~~

~~B16.18-2012.....Cast Copper Alloy Solder Joint Pressure
Fittings~~

~~B16.26-2013.....Cast Copper Alloy Fittings for Flared Copper
Tubes~~

~~B18.2.2-2015.....Nuts for General Applications: Machine Screw
Nuts, Hex, Square, Hex Flange, and Coupling
Nuts (Inch Series)~~

~~B18.5.2.1M-2006 (R2011).Metric Round Head Short Square Neck Bolts~~

~~ASME Boiler and Pressure Vessel Code -~~

~~BPVC Section IX-2015.....Welding, Brazing, and Fusing Qualifications~~

~~C. American Society of Safety Engineers (ASSE):~~

~~1003-2009 Water Pressure Reducing Valves~~

~~D. American Society for Testing and Materials (ASTM):~~

~~A36/A36M-2014.....Standard Specification for Carbon Structural
Steel~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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~~A47/A47M-1999 (R2014)...Standard Specification for Ferritic Malleable
Iron Castings~~
~~A48/A48M-2003 (R2012)...Standard Specification for Gray Iron Castings~~
~~A148/A148M-2015a.....Standard Specification for Steel Castings, High
Strength, for Structural Purposes~~
~~A307-2014.....Standard Specification for Carbon Steel Bolts,
Studs, and Threaded Rod 60,000 PSI Tensile
Strength~~
~~A536-1984 (R2014).....Standard Specification for Ductile Iron
Castings~~
~~A563-2015.....Standard Specification for Carbon and Alloy
Steel Nuts~~
~~B61-2015.....Standard Specification for Steam or Valve
Bronze Castings~~
~~B62-2015.....Standard Specification for Composition Bronze
or Ounce Metal Castings~~
~~B88-2014.....Standard Specification for Seamless Copper
Water Tube~~
~~B117-2011.....Standard Practice for Operating Salt Spray
(Fog) Apparatus~~
~~B633-2013.....Standard Specification for Electrodeposited
Coatings of Zinc on Iron and Steel~~
~~C443-2012.....Standard Specification for Joints for Concrete
Pipe and Manholes, Using Rubber Gaskets~~
~~C857-2014.....Standard Practice for Minimum Structural Design
Loading for Underground Precast Concrete
Utility Structures~~
~~C858-2010e1.....Standard Specification for Underground Precast
Concrete Utility Structures~~
~~D1785-2015.....Standard Specification for Poly(Vinyl Chloride)
(PVC) Plastic Pipe, Schedules 40, 80, and 120~~
~~D2000-2012.....Standard Classification System for Rubber
Products in Automotive Applications~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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~~D2464-2015~~	~~Standard Specification for Threaded Poly(Vinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 80~~
~~D2467-2015~~	~~Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80~~
~~D2672-2014~~	~~Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement~~
~~D4101-2014~~	~~Standard Specification for Polypropylene Injection and Extrusion Materials~~
~~F437-2015~~	~~Standard Specification for Threaded Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80~~
~~F439-2013~~	~~Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80~~
~~F441/F441M-2015~~	~~Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80~~
~~F477-2014~~	~~Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe~~
~~F593-2013a~~	~~Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs~~
~~E. American Water Works Association (AWWA):~~	
~~B300-2010~~	~~Hypochlorites~~
~~B301-2010~~	~~Liquid Chlorine~~
~~C104-2013~~	~~Cement-Mortar Lining for Ductile-Iron Pipe and Fittings~~
~~C105-2010~~	~~Polyethylene Encasement for Ductile-Iron Pipe Systems~~
~~C110-2012~~	~~Ductile-Iron and Gray-Iron Fittings~~
~~C111-2012~~	~~Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

~~C115-2011.....Flanged Ductile-Iron Pipe with Ductile-Iron or
Gray-Iron Threaded Flanges~~

~~C150-2014.....Thickness Design of Ductile-Iron Pipe~~

~~C151-2009.....Ductile-Iron Pipe, Centrifugally Cast~~

~~C153-2011.....Ductile-Iron Compact Fittings~~

~~C502-2014.....Dry-Barrel Fire Hydrants~~

~~C504-10.....Rubber-Seated Butterfly Valves~~

~~C508-2009.....Swing-Check Valves for Waterworks Service, 50
mm thru 600 mm (2 inches through 24 inches) NPS~~

~~C509-2009.....Resilient-Seated Gate Valves for Water Supply
Service~~

~~C510-2007.....Double Check Valve Backflow Prevention Assembly~~

~~C511-2007.....Reduced-Pressure Principle Backflow Prevention
Assembly~~

~~C512-07.....Air Release, Air/Vacuum and Combination Air
Valves~~

~~C550-2013.....Protective Interior Coatings for Valves and
Hydrants~~

~~C600-2010.....Installation of Ductile Iron Water Mains and
Their Appurtenances~~

~~C605-2013.....Underground Installation of Polyvinyl Chloride
(PVC) and Molecularly Oriented Polyvinyl
Chloride (PVCO) Pressure Pipe and Fittings~~

~~C651-2014.....Disinfecting Water Mains~~

~~C700-2015.....Cold-Water Meters - Displacement Type, Metal
Alloy Main Case~~

~~C701-2015.....Cold-Water Meters - Turbine Type, for Customer
Service~~

~~C702-2015.....Cold-Water Meters - Compound Type~~

~~C706-2010 (Withdrawn)....Direct-Reading, Remote-Registration Systems for
Cold-Water Meters~~

~~C707-2010.....Encoder-Type Remote-Registration Systems for
Cold-Water Meters~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- ~~C800-2014.....Underground Service Line Valves and Fittings~~
- ~~C900-2007.....Polyvinyl Chloride (PVC) Pressure Pipe and
Fabricated Fittings, 100 mm Through 300 mm (4
inches Through 12 inches), for Water
Transmission and Distribution~~
- ~~C906-15.....Polyethylene (PE) Pressure Pipe and Fittings, 4
In. (100 mm) Through 64 In. (1,600 mm), for
Water Distribution and Transmission~~
- ~~F. American Welding Society (AWS):~~
- ~~A5.8/A5.8M-2011.....Specification for Filler Metals for Brazing and
Brazing Welding~~
- ~~G. Copper Development Association, Inc. (CDA):~~
- ~~A4015.....Copper Tube Handbook~~
- ~~H. National Fire Protection Association (NFPA):~~
- ~~24-2016.....Standard for the Installation of Private Fire
Service Mains and Their Appurtenances~~
- ~~I. NSF International:~~
- ~~61-2014a.....Drinking Water System Components-Health Effects~~
- ~~J. University of Southern California Foundation for Cross Connection
Control and Hydraulic Research (USC FCCCHR):~~
- ~~9th Edition.....Manual of Cross-Connection Control.~~

1.4 SUBMITTALS

- ~~A. Submittals, including number of required copies, shall be submitted in
accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND
SAMPLES.~~
- ~~B. Information and material submitted under this section shall be marked
"SUBMITTED UNDER SECTION 33 10 00, WATER UTILITIES", with applicable
paragraph identification.~~
- ~~C. Make all necessary field measurements and investigations to assure that
the equipment and assemblies will meet contract requirements and will
fit the space available.~~
- ~~D. If equipment is submitted which differs in arrangement from that shown,
provide drawings that show the rearrangement of all associated systems.~~

Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft-AE Project No. 22-113

01/16/24

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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~~Approval by VA will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract.~~

~~E. Prior to submitting shop drawings for approval, certify in writing that manufacturers of all major items of equipment have each reviewed drawings and specifications, and have jointly coordinated and properly integrated their equipment and controls to provide a complete and efficient installation.~~

~~F. Provide lists of previous installations by the installing contractor. Contact persons who will serve as references, with telephone numbers and e-mail addresses shall be submitted with the references.~~

~~G. Manufacturers' Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity. Submit all items as one package. Ductile iron pipe and Polyvinyl Chloride (PVC) shall be in accordance with AWWA C600 and AWWA C605 respectively.~~

- ~~1. Piping.~~
- ~~2. Fittings~~
- ~~3. Gaskets.~~
- ~~4. Valves.~~
- ~~5. Fire hydrants.~~
- ~~6. Meter.~~
- ~~7. Vaults, frames and covers.~~
- ~~8. Steps.~~
- ~~9. Backflow Preventer~~
- ~~10. Post indicator.~~
- ~~11. Valve boxes.~~
- ~~12. Corporation and curb stops.~~
- ~~13. Curb stop boxes.~~
- ~~14. Joint restraint.~~
- ~~15. Disinfection products.~~
- ~~16. Warning Tape~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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~~17. Link/sleeve seals.~~

~~H. Submittals and shop drawings for interdependent items, containing applicable descriptive information, shall be furnished together and complete in a group. Coordinate and properly integrate materials and equipment in each group to provide a compatible and efficient installation. Final review and approvals will be made only by groups.~~

~~I. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:~~

- ~~1. Include complete list indicating all components of the systems.~~
- ~~2. Include complete diagrams of the internal wiring for each item of equipment.~~
- ~~3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.~~

~~J. Testing Certifications:~~

- ~~1. Certification of Backflow Devices.~~
- ~~2. Hydrostatic Testing.~~
- ~~3. Certification of Disinfection, including free chlorine residuals, and bacteriological examinations.~~

~~K. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.~~

~~L. Submit training plans and instructor qualifications in accordance with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.~~

~~1.5 QUALITY ASSURANCE~~

~~A. Products Criteria:~~

- ~~1. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture, supply, and servicing of the specified products for at least 5 years. However, digital electronics devices, software, and systems such as controls, instruments, and computer work station, shall be~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- ~~the current generation of technology and basic design that has a proven satisfactory service record of at least 5 years.~~
- ~~2. Equipment Service: There shall be permanent service organizations, authorized and trained by manufacturers of the equipment supplied, located within 160 km (100 miles) of the project. These organizations shall come to the site and provide acceptable service to restore operations within four hours of receipt of notification by phone, e-mail, or fax in event of an emergency, such as the shut-down of equipment; or within 24 hours in a non-emergency. Names, mail, e-mail addresses, and phone numbers of service organizations providing service under these conditions for (as applicable to the project): pumps, compressors, water heaters, critical instrumentation, computer workstation, and programming shall be submitted for project record and inserted into the operations and maintenance manual.~~
 - ~~3. All items furnished shall be free from defects that would adversely affect the performance, maintainability, and appearance of individual components and overall assembly.~~
 - ~~4. The products and execution of work specified in Division 33 shall conform to the referenced codes and standards as required by the specifications. Local codes and amendments enforced by the local code official shall be enforced, if required by local authorities such as the natural gas supplier. If the local codes are more stringent, then the local code shall apply. Any conflicts shall be brought to the attention of the (COR).~~
 - ~~5. Multiple Units: When two or more units of the same type or class of materials or equipment are required, these units shall be the product of one manufacturer.~~
 - ~~6. Assembled Units: Ensure that manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.~~
 - ~~7. Nameplate: Nameplate bearing manufacturer's name or identifiable trademark securely affixed in a conspicuous place on equipment or~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- ~~name or trademark cast integrally with equipment, stamped, or otherwise permanently marked on each item of equipment.~~
- ~~8. Use of asbestos containing products, equipment, or materials is prohibited.~~
- ~~B. Comply with the rules and regulations of the Public Utility having jurisdiction over the connection to Public Water lines and the extension, and/or modifications to Public Utility systems.~~
- ~~C. Comply with all rules and regulations of Federal, State, and Local Health Department and Department of Environmental Quality having jurisdiction over the design, construction, and operation of potable water systems.~~
- ~~D. Manufacturer's Recommendations: Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed and electronic copies of these recommendations shall be furnished to the COR prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.~~
- ~~E. Welding: Before any welding is performed, submit a certificate certifying that welders comply with the following requirements:~~
- ~~1. Qualify welding processes and operators for piping according to ASME BPVC Section IX.~~
 - ~~2. Comply with provisions of ASME B31 series "Code for Pressure Piping".~~
 - ~~3. Certify that each welder and welding operator has passed American Welding Society (AWS) qualification tests for the welding processes involved, and that certification is current.~~
 - ~~4. All welds shall be stamped according to the provisions of the American Welding Society.~~
- ~~F. Execution (Installation, Construction) Quality:~~
- ~~1. All items shall be applied and installed in accordance with manufacturer's written instructions. Conflicts between the manufacturer's instructions and the contract documents shall be~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- ~~referred to the COR for resolution. Printed copies or electronic files of manufacturer's installation instructions shall be provided to the COR at least 10 working days prior to commencing installation of any item.~~
- ~~2. All items that require access, such as for operating, cleaning, servicing, maintenance, and calibration, shall be easily and safely accessible by persons standing at floor level, or standing on permanent platforms, without the use of portable ladders. Examples of these items include, but are not limited to: all types of valves, filters and strainers, transmitters, and control devices. Prior to commencing installation work, refer conflicts between this requirement and contract documents to COR for resolution.~~
 - ~~3. Complete layout drawings shall be required by Paragraph, SUBMITTALS. Construction work shall not start on any system until the layout drawings have been approved by VA.~~
 - ~~4. Installer Qualifications: Installer shall be licensed and shall provide evidence of the successful completion of at least five projects of equal or greater size and complexity. Provide tradesmen skilled in the appropriate trade.~~
 - ~~5. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or additional time to the Government.~~
- ~~G. Cleanliness of Piping and Equipment Systems:~~
- ~~1. Care shall be exercised in the storage and handling of equipment and piping material to be incorporated in the work. Debris arising from cutting, threading, and welding of piping shall be removed.~~
 - ~~2. Piping systems shall be flushed, blown, or pigged as necessary to deliver clean systems.~~
 - ~~3. The interior of all tanks shall be cleaned prior to delivery and beneficial use by the Government. All piping shall be tested in accordance with the specifications and the International Plumbing Code (IPC). All filters, strainers, and fixture faucets shall be flushed of debris prior to final acceptance.~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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~~4. Contractor shall be fully responsible for all costs, damage, and delay arising from failure to provide clean systems.~~

~~H. All material surfaces in contact with potable water shall comply with NSF 61.~~

~~1.6 DELIVERY, STORAGE, AND HANDLING~~

~~A. Protection of Equipment:~~

~~1. Equipment and material placed on the job site shall remain in the custody of the Contractor until final acceptance, whether or not the Government has reimbursed the Contractor for the equipment and material. The Contractor is solely responsible for the protection of such equipment and material against any damage.~~

~~2. Damaged equipment shall be replaced with an identical unit as determined and directed by the COR. Such replacement shall be at no additional cost or additional time to the Government.~~

~~3. Interiors of new equipment and piping systems shall be protected against entry of foreign matter. Both inside and outside shall be cleaned before painting or placing equipment in operation.~~

~~4. Existing equipment and piping being worked on by the Contractor shall be under the custody and responsibility of the Contractor and shall be protected as required for new work.~~

~~1.7 AS-BUILT DOCUMENTATION~~

~~A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.~~

~~B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

~~spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.~~

- ~~C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them on Auto-Cad version 2024 provided on CD or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement.~~
- ~~D. Certification documentation shall be provided to COR 10 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and a certification that all results of tests were within limits specified.~~

~~PART 2 - PRODUCTS~~

~~2.1 DUCTILE IRON PIPE AND FITTINGS~~

- ~~A. Ductile iron pipe, direct buried:~~
- ~~1. Provide ductile iron pipe conforming to the requirements of AWWA C151, Pressure Class 350 for Pipe 100 mm through 300 mm (4 inches through 12 inches) in diameter with double thickness cement mortar lining interior, interior asphaltic seal coat, and exterior asphaltic coating, in accordance with AWWA and ANSI Standards.~~
 - ~~2. Below Grade: Supply pipe in lengths not in excess of a nominal 6.1 m (20 feet) with rubber ring type push-on joints, mechanical joint, or approved restrained joint. Provide mechanical and restrained joint pipe with sufficient quantities of accessories as required for each joint.~~
 - ~~3. When a polyethylene encasement over pipe, fittings, and valves is a requirement as indicated on the drawings, the material,~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

~~installation, and workmanship shall conform to applicable sections of AWWA C105. Make provisions to keep the polyethylene from direct exposure to sunlight prior to installation. Backfill following installation without delay to avoid exposure to sunlight.~~

~~B. Ductile Iron Pipe Above Grade or in Below Ground Concrete Pits:~~

- ~~1. Flanged ductile iron pipe, AWWA C115, with factory applied screwed long hub flanges except as otherwise specified hereinafter. Provide flange joint pipe where shown on the drawings. Face and drill flanges after being screwed on the pipe, with flanges true to 90 degrees with the pipe axis and flush with end of pipe, ANSI B16.1, 861 kPa (125 psi) or 1724 kPa (250 psi) standard, for the purpose intended.~~
- ~~2. Wall Sleeve Castings: Size and types shown on the drawings and as herein specified in paragraph LINK/SLEEVE SEALS.~~
- ~~3. Pipe Thickness Class: Minimum of Class 53 as defined in AWWA C150 for all sizes of flanged pipe.~~
- ~~4. Rubber Ring Gaskets: Full face type, AWWA C111, 1.6 mm (1/16 inch) rubber ring gaskets and of approved composition suitable for the required service.~~
- ~~5. Pipe and fittings exposed to view in the finished work are to be painted in accordance with Section 09 91 00, PAINTING. Pipe shall not receive the standard tar or asphalt coat on the outside surfaces but shall be shop-primed on the outside with one coat of the pipe manufacturer standard color of rust inhibitive primer or equal. Finished paint color shall be as selected for the location.~~
- ~~6. Bolts and Nuts on Flanged Fittings: Grade B, ASTM A307. Low alloy, high strength steel in accordance with AWWA C111. Assemble stainless steel bolts and nuts using anti-seize compound to prevent galling.~~

~~C. All Pipe Fittings: Ductile iron with a minimum pressure rating of 2413 kPa (350 psi). Fittings shall meet the requirements of ANSI and AWWA specifications as applicable. Rubber gasket joints shall conform to AWWA C111 for mechanical and push-on type joints. Ball joints shall conform to AWWA C151 with a separately cast ductile iron bell~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

~~conforming to ASTM A148/A148M. Flanged fittings shall conform to AWWA C115 and be furnished flat faced and drilled to 861 kPa (125 psi) or 1724 kPa (250 psi) template in accordance with ANSI B16.1 with full faced gaskets.~~

~~D. Provide cement mortar lining and bituminous seal coat on the inside of the pipe and fittings in accordance with AWWA C104. Provide standard asphaltic coating on the exterior.~~

~~E. Provide a factory hydrostatic test of not less than 3.5 MPa (500 psi) for all pipe in accordance with AWWA C151.~~

2.2 POLYVINYL CHLORIDE PIPE AND FITTINGS

~~A. Class-Rated Polyvinyl Chloride (PVC) Pipe: Pipe and accessories shall bear the NSF mark indicating pipe size, manufacturer's name, AWWA and/or ASTM Specification number, working pressure, and production code.~~

~~1. PVC pipe and accessories 100 mm to 355 mm (4 inches to 14 inches) in diameter, AWWA C900, Class 200, DR 14, cast iron outside diameters, unless otherwise shown or specified.~~

~~2. PVC Pipe and Accessories Smaller than 100 mm (4 inches): Schedule 80, meeting the requirements of ASTM D1785, Type 1, Grade 1. All exposed piping shall be CPVC meeting requirements of ASTM F441/F441M.~~

~~B. Joints:~~

~~1. Pipe 75 mm (3 inches) and Greater in Diameter: Push-on type with factory installed solid cross section elastomeric ring meeting the requirements of ASTM F477.~~

~~2. Pipe Less Than 75 mm (3 inches) in Diameter: Threaded (ASTM D2464) or solvent welded (ASTM D2672). Use Teflon tape or liquid Teflon thread lubricant approved for use on plastic on all threaded joints.~~

~~C. Fittings:~~

~~1. Class-Rated Pipe 75 mm (3 inches) in Diameter and Greater: Ductile iron with mechanical joints conforming to the requirements of AWWA C153. Mechanical joint fittings shall include retainer glands, unless otherwise noted.~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- ~~2. For Schedule 80 Pipe less than 75 mm (3 inches) in Diameter:
Threaded or solvent weld. Threaded PVC fittings shall conform to
ASTM D2464. Solvent welded fittings shall conform to ASTM D2467.
CPVC fittings shall conform to ASTM F437 for threaded fittings and
ASTM F439 for solvent weld fittings.~~

~~2.3 MECHANICAL JOINT RETAINER GLANDS~~

- ~~A. Restraint devices for mechanical joint fittings and appurtenances
conforming to either AWWA C111 or AWWA C153, shall conform to the
following:~~
- ~~1. Restraint devices for nominal pipe sizes 75 mm (3 inch) through 900
mm (36 inch) shall consist of multiple gripping wedges incorporated
into a follower gland meeting the applicable requirements of AWWA
C110.~~
 - ~~2. The devices shall have a working pressure rating equal to that of
the pipe on which it is used. Ratings are for water pressure and
must include a minimum safety factor of 2:1 in all sizes.~~
 - ~~3. Gland body, wedges, and wedge actuating components shall be cast
from grade 65-45-12 ductile iron material in accordance with ASTM
A536. Ductile iron gripping wedges shall be heat treated within a
range of 370 to 470 Brinell Hardness Number (BHN).~~
 - ~~4. An identification number consisting of year, day, plant, and shift
(YYDDD) (plant designation) (Shift number), shall be cast into each
gland body. All physical and chemical test results shall be recorded
such that they can be accessed via the identification number on the
casting. All components shall be manufactured in the United States.~~
 - ~~5. Mechanical Joint restraint shall require conventional tools and
installation procedures per AWWA C600, while retaining full
mechanical joint deflection during assembly. Proper actuation of the
gripping wedges shall be ensured with torque limiting twist off
nuts.~~
 - ~~6. Mechanical joint restraints shall be listed by Underwriters
Laboratories, and approved by Factory Mutual in the 75 mm (3 inch)
through 300 mm (12 inch) sizes.~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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~~7. All casting bodies shall be surface pretreated with a phosphate wash, rinse, and sealer before drying. The coating shall be electrostatically applied and heat cured. The coating shall be a polyester-based powder to provide corrosion, impact, and UV resistance.~~

~~2.4 COPPER PIPE AND TUBING~~

~~A. Copper Piping: ASTM B88, Type K, or Type L with flared fittings in accordance with AWWA C800, with sweat cast brass fittings per ANSI B16.18. Use brazing alloy, AWS A5.8/A5.8M, Classification BCuP. Fittings for compression-type joint, ASME B16.26, flared tube type.~~

~~2.5 VALVES~~

~~A. Gate:~~

~~1. Unless otherwise specified, valves shall conform to AWWA C509 with mechanical-joint ends. Valves 75 mm (3 inches) and greater shall be resilient seated, ductile iron body, bronze mounted inclined seats, non-rising stem type, turning counter-clockwise to open, with a minimum 1380 kPa (200 psi) WOG. The resilient seat shall be fastened to the gate with stainless steel fasteners or vulcanizing methods. The interior and exterior shall be coated with thermo-setting or fusion epoxy coating in accordance with AWWA C550. Stuffing boxes shall have O-ring stem seals. Stuffing boxes shall be bolted and constructed so as to permit easy removal of parts for repair. Asbestos packing is prohibited.~~

~~2. Operator:~~

- ~~a. Underground: Except for use with post indicators, furnish valves with 50 mm (2 inch) nut for socket wrench operation.~~
- ~~b. Above Ground and in Pits: Hand wheels.~~

~~3. Joints: Ends of valves shall accommodate, or be adapted to, pipe installed.~~

~~B. Check Valve: Check valves shall be designed for a minimum working pressure of 150 psi or as indicated. Valves shall have a clear waterway equal to the full nominal diameter of the valve. Valves shall open to permit flow when inlet pressure is greater than the discharge pressure,~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

~~and shall close tightly to prevent return flow when discharge pressure exceeds inlet pressure. The size of the valve, working pressure, manufacturer's name, initials, and trademark shall be cast on the body of each valve. Valves 50 mm (2 inches) and greater shall be outside lever and spring type.~~

~~1. Smaller than 100 mm (4 inches): Bronze body and bonnet, ASTM B61 or ASTM B62, 1380 kPa (200 psi) WOG.~~

~~2. 100 mm (4 inches) and Greater: Iron body, bronze trim, swing type, vertical or horizontal installation, flange connection, 1380 kPa (200 psi) WOG. Check valves shall conform to AWWA C508 and shall be epoxy coated and lined per AWWA C550.~~

~~C. Corporation Stops and Saddles: Ground key type; bronze, ASTM B61 or ASTM B62; and suitable for the working pressure of the system. Ends shall be suitable for solder-joint or flared tube compression type joint. Threaded ends for inlet and outlet of corporation stops, AWWA C800; coupling nut for connection to flared copper tubing, ASME B16.26.~~

~~D. Curb or Service Stops: Ground key, round way, inverted key type; made of bronze, ASTM B61 or ASTM B62; and suitable for the working pressure of the system. Ends shall be as appropriate for connection to the service piping. Arrow shall be cast into body of the curb or service stop indicating direction of flow. Smaller than 75 mm (3 inches). Waterworks standard for Type "K" copper, single piece cast bronze body with tee top operated plug sealed with O-ring gaskets, 1380 kPa (200 psi) WOG per AWWA C800.~~

~~E. Vacuum and Air Relief Valves: Vacuum and air relief valves shall be of the size shown and shall be of a type that will release air and prevent the formation of a vacuum. The valves shall automatically release air when the lines are being filled with water and shall admit air into the line when water is being withdrawn in excess of the inflow. Valves shall be iron body with bronze trim and stainless steel float. Valves shall be rated for the same operating pressure as the pipeline.~~

~~F. Pressure Reducing Valves: Pressure reducing valves shall maintain a constant downstream pressure regardless of fluctuations in demand.~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

~~Valves shall be suitable for 1724 kPa (250 psi) operating pressure on the inlet side, with outlet pressure set for 463 kPa (70 psi). The valves shall be of the hydraulically-operated, pilot controlled, globe or angle type, and may be actuated either by diaphragm or piston. The pilot control shall be the diaphragm-operated, adjustable, spring-loaded type designed to permit flow when controlling pressure exceeds the spring setting. Ends shall be flanged. Valve bodies shall be bronze, cast iron, or cast steel with bronze trim. Valve stem shall be stainless steel. Valve discs and diaphragms shall be synthetic rubber. Valve seats shall be bronze. Pilot controls shall be bronze with stainless steel working parts.~~

~~2.6 TRACER WIRE FOR NONMETALLIC PIPING~~

~~A. Provide bare copper or aluminum wire not less than 2.5 mm (0.10 inch) in diameter in sufficient length to be continuous over each separate run of nonmetallic pipe.~~

~~2.7 WARNING TAPE~~

~~A. Standard, 0.10 mm (4-mil) polyethylene 75 mm (3 inch) wide tape, detectable type, blue with black letters, and imprinted with "CAUTION BURIED WATER LINE BELOW".~~

~~2.8 CURB STOP BOX~~

~~A. Cast iron extension box with screw or slide type adjustment and flared base. Box shall be adapted, without full extension, to depth of cover required over pipe at stop location. Cast the word "WATER" in cover and set cover flush with finished grade. Curb stop shut-off rod shall extend 600 mm (2 feet) above top of deepest stop box.~~

~~2.9 VALVE BOX~~

~~A. Cast iron extension box with screw or slide-type adjustment and flared base. Minimum thickness of metal shall be 5 mm (3/16 inch). Box shall be adapted, without full extension, to depth of cover required over pipe at valve location. Cast the word "WATER" in cover. Provide two (2) "T" handle socket wrenches of 18 mm (5/8 inch) round stock long enough to extend 600 mm (2 feet) above top of deepest valve box. The least diameter of the shaft of the box shall be 135 mm (5-1/4 inches). Cast~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

~~iron box shall have a heavy coat of bituminous paint. Valve box and cover shall be installed where indicated on the drawings to be utilized as access points for the tracer wire or detectable warning tape.~~

~~2.10 POST INDICATOR VALVE~~

~~A. Valve: Valve shall conform to the specifications listed in paragraph VALVES for gate valves. The Post Indicator shall conform to NFPA 24 and shall be fully compatible with the valve and all the supervisory switches.~~

~~2.11 FIRE HYDRANTS~~

~~A. Size of main valve opening of each hydrant shall be 135 mm (5-1/4 inches), minimum. Hose thread, size of fire apparatus connection, and shape, size, and direction of rotation of operating head of hydrant shall be identical with present local fire department and/or water department standards.~~

~~B. Hydrant shall be type AWWA C502, heavy construction, of proper length to connect pipe without extra fittings, and shall be the traffic type with safety flange on barrel and safety couplings on the valve stem with the following features:~~

- ~~1. Interior removable without digging up hydrant; can be packed under pressure; one 115 mm (4-1/2 inch) pumper connection and two 65 mm (2-1/2 inch) hose connections with caps securely chained to barrel; suitable drainage device; single rubber or leather-faced valve in base; nozzles, stuffing boxes, wedge nuts, seat rings, clamp plates, etc. Threaded joints or spindles shall be bronze. Upper and lower barrels shall be of equal diameters. Upper barrel shall be of sufficient length to permit setting hydrant with barrel flange not more than 50 mm (2 inches) above finished grade. All fire hydrants shall have 150 mm (6 inch) bottom connection. Size and shape of operating nut, cap nuts, and threads on hose and pumper connections shall be as specified in AWWA C502.~~
- ~~2. Provide fire hydrants with a finish paint identical to the existing fire hydrants. If there are no existing hydrants, contact the~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

~~nearest fire department responder (fire department) to the site for appropriate color.~~

~~C. Provide two wrenches with handles not less than 355 mm (14 inches) long.~~

2.12 TAPPING SLEEVES

~~A. Tapping sleeves of the sizes indicated for connection to existing main shall be the cast gray, ductile, stainless steel or malleable iron, split-sleeve type with flanged or grooved outlet, and with bolts, follower rings, and gaskets on each end of the sleeve. Construction shall be suitable for a maximum working pressure of 1035 kPa (150 psi). Bolts shall have square heads and hexagonal nuts. Longitudinal gaskets and mechanical joints with gaskets shall be as recommended by the manufacturer of the sleeve. When using grooved mechanical tee, it shall consist of an upper housing with full locating collar for rigid positioning which engages a machine-cut hole in pipe, encasing an elastomeric gasket which conforms to the pipe outside diameter around the hole and a lower housing with positioning lugs, secured together during assembly by nuts and bolts as specified, pre-torqued to 67.8 Newton-meters (50 foot-pounds).~~

2.13 PIPE SLEEVES

~~A. Cast gray ductile iron or zinc coated steel.~~

2.14 SLEEVE-TYPE MECHANICAL COUPLINGS

~~A. Couplings shall be designed to couple plain-end piping by compression of a ring gasket at each end of the adjoining pipe sections. The coupling shall consist of one middle ring flared or beveled at each end to provide a gasket seat; two follower rings; two resilient tapered rubber gaskets; and bolts and nuts to draw the follower rings toward each other to compress the gaskets. The middle ring and the follower rings shall be true circular sections free from irregularities, flat spots, and surface defects; the design shall provide for confinement and compression of the gaskets. For ductile iron and PVC plastic pipe, the middle ring shall be of cast iron or steel; and the follower rings shall be of malleable or ductile iron. For steel piping, the middle~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

~~ring shall be of steel and the follower rings shall be of steel or malleable iron. Cast iron, ASTM A48/A48M not less than Class 25. Malleable and ductile iron shall conform to ASTM A47/A47M and ASTM A536, respectively. Steel shall have a strength not less than that of the pipe. Gaskets shall be designed for resistance to set after installation and shall meet the applicable requirements specified for gaskets for mechanical joint in AWWA C111. Bolts shall be track-head type, ASTM A307, Grade A, with nuts, ASTM A563, Grade A; or round-head square-neck type bolts, ASME B18.5.2.1 or with hex nuts, ASME B18.2.2. Bolts shall be 18 mm (5/8 inch) in diameter; minimum number of bolts for each coupling shall be per coupling manufacturers specifications. Bolt holes in follower rings shall be of a shape to hold fast the necks of the bolts used. Mechanically coupled joints using a sleeve-type mechanical coupling shall not be used as an optional method of jointing except where pipeline is adequately anchored to resist tension pull across the joint. Mechanical couplings shall provide a tight flexible joint under all reasonable conditions, such as pipe movements caused by expansion, contraction, slight setting or shifting in the ground, minor variations in trench gradients, and traffic vibrations. Couplings shall be of strength not less than the adjoining pipeline.~~

2.15 BACKFLOW PREVENTER

- ~~A. Potable Water and Irrigation Water Service: Reduced Pressure Principle Type AWWA C511, except pressure drop at rated flow shall not exceed 103 kPa (15 psi). Gate valves installed on the assembly shall be resilient seated valve conforming to AWWA C509.~~
- ~~B. Fire Service: Double detector check valve. AWWA C510 and NFPA 24.~~
- ~~C. In cold climate areas, backflow assemblies and devices shall be protected from freezing by a method acceptable to local jurisdiction.~~
- ~~D. Backflow preventers shall be approved by the Foundation for Cross Connection Control and Hydraulic Research (USC FCCCHR) of the Manual of Cross-Connection Control.~~
- ~~E. Backflow preventer shall not be located in any area containing fumes that are toxic, poisonous, or corrosive.~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- ~~F. Direct connections between potable water piping and sewer connected wastes shall not exist under any condition with or without backflow protection.~~
- ~~G. Backflow preventer shall be accessed and have clearance for the required testing, maintenance, and repair. Access and clearance shall require a minimum of 300 mm (1 foot) between the lowest portion of the assembly and grade, floor, or platform. Installations elevated more than 1500 mm (5 feet) above the floor or grade shall be provided with a permanent platform capable of supporting a tester or maintenance person.~~

2.16 CONCRETE VAULTS

- ~~A. Precast, reinforced-concrete vault: ASTM C858, designed for AASHTO HS20-44 load designation.~~
- ~~1. Ladder: ASTM A36/A36M, steel or polyethylene-encased steel steps.~~
 - ~~2. Drain: ASME A112.6.3, cast iron floor drain with outlet. Include body anchor flange, light-duty cast iron grate, bottom outlet, and integral or field-installed bronze ball or clapper-type backwater valve.~~
 - ~~3. Manhole Frame and Cover: ASTM A48/A48M, Class No. 35A minimum tensile strength, gray cast iron, 600 mm (24 inch) minimum diameter, unless otherwise indicated.~~

2.17 CAST IRON FRAME AND COVER, STEPS, ETC.

- ~~A. Frames and Covers: Shall be cast iron or ductile iron. Cast iron frames and covers shall be as indicated or shall be of type suitable for the application, circular, without vent holes. The frames and covers shall have a combined weight of not less than 181 Kg (400 lbs.). The word "WATER" shall be stamped or cast into covers so that it is plainly visible.~~
- ~~B. Manhole Steps: Plastic or rubber coated, pressure-molded to the steel. Plastic coating shall conform to ASTM D4101, copolymer polypropylene. Rubber shall conform to ASTM C443, except shore A durometer hardness shall be 70 plus or minus 5. Aluminum steps or rungs are prohibited. Steps are not required in manholes less than 1.2 m (4 feet) deep.~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

~~2.18 POTABLE WATER~~

- ~~A. Water used for filling, flushing, and disinfection of water mains and appurtenances shall conform to Safe Drinking Water Act.~~

~~2.19 DISINFECTION CHLORINE~~

- ~~A. Liquid chlorine shall conform to AWWA B301 and AWWA C651.~~
- ~~B. Sodium hypochlorite shall conform to AWWA B300 with 5 percent to 15 percent available chlorine.~~
- ~~C. Calcium hypochlorite shall conform to AWWA B300 supplied in granular form or 5 gram tablets, and shall contain 65 percent chlorine by weight.~~

~~2.20 LINK/SLEEVE SEALS~~

- ~~A. The seal assemblies shall be modular, mechanical type, consisting of inter-locking synthetic rubber links shaped to continuously fill the annular space between the pipe and the wall opening. The elastomeric element shall be sized and selected per the manufacturer's recommendations and have the following properties as designated by ASTM: 1) coloration shall be throughout elastomer for positive field inspection; 2) each link shall have a permanent identification of the size and manufacturer's name molded into it.~~
- ~~1. For Standard Service Applications: EPDM = ASTM D2000 M3BA510, Color = Black~~
- ~~2. For Hydrocarbon Service Applications: Nitrile = ASTM D2000 M1BF510, Color = Green~~
- ~~3. For High Temperature of Fire Seal Applications: Silicone = ASTM D2000 M1GE505, Color = Gray~~
- ~~B. The modular seal hardware for fastening the links shall be sized according to the manufacturer's recommendations for the service intended. Bolts, flange hex nuts shall be:~~
- ~~1. Mild Steel with a 415 MPa (60,000 psi) minimum tensile strength and 2-part Zinc Dichromate coating per ASTM B633 and Organic Coating, tested in accordance with ASTM B117 to pass a 1,470 hour salt spray test.~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- ~~C. Quality Assurance: Manufacturer's modular seal components and systems shall be domestically manufactured at a plant with a current ISO-9002 registration. Copy of the ISO-9002 registrations shall be provided with the submittal for these items.~~
- ~~D. Water Stop Wall Sleeve: Unless otherwise shown or specified, install molded non-metallic high density polyethylene sleeves having an integrally formed hollow water stop. Water stop shall be sized a minimum of 100 mm (4 inches) larger than the outside diameter of the sleeve itself and allowing 1/2 movement between wall forms to resist pour forces. Each sleeve assembly shall have end caps manufactured of the same material as the sleeve itself installed at each end of the sleeve so as to prevent deformation during the initial concrete pour and to facilitate attaching the sleeve to the wall forms. End caps shall remain in place to protect the opening from residual debris and rodent entry prior to pipe insertion. The wall sleeve shall be manufactured by the same company as the modular seal assembly.~~

PART 3 - EXECUTION

3.1 INSTALLATION

- ~~A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.~~

3.2 BUILDING SERVICE LINES

- ~~A. Install water service lines to point of connection within approximately 1500 mm (5 feet) outside of buildings to which such service is to be connected and make connections thereto. If building services have not been installed, provide temporary caps.~~

3.3 REGRADING

- ~~A. Raise or lower existing valve and curb stop boxes, or any other applicable water system facilities, to finish grade in areas being graded.~~

3.4 PIPE LAYING, GENERAL

- ~~A. Care shall be taken in loading, transporting, and unloading to prevent injury to the pipe or coatings. Pipe or fittings shall not be dropped.~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- ~~All pipe or fittings shall be examined before laying, and no piece shall be installed which is found to be defective. Any damage to the pipe coatings shall be repaired as recommended by the manufacturer in order to maintain the product performance as if it were undamaged.~~
- B. ~~All pipe and fittings shall be inspected just prior to being laid or installed. If any defective piping is discovered after it has been laid, it shall be removed and replaced with a sound pipe in a satisfactory manner at no additional cost or time to the Government. All pipe and fittings shall be thoroughly cleaned before laying, shall be kept clean until they are used in the work, and when installed or laid, shall conform to the lines and grades required.~~
- C. ~~All buried piping shall be installed to the lines and grades as shown on the drawings. All underground piping shall slope uniformly between joints where elevations are shown. If elevations are not indicated, pipe shall have a minimum depth of cover of 1 m (3 feet).~~
- D. ~~Exercise extreme care when installing piping to shore up and protect from damage all existing utilities and structures.~~
- E. ~~Do not lay pipe on unstable material, in wet trench, or when trench or weather conditions are unsuitable.~~
- F. ~~Do not lay pipe in same trench with other pipes or utilities unless shown otherwise on drawings.~~
- G. ~~Hold pipe securely in place while joint is being made.~~
- H. ~~Do not walk on pipes in trenches until covered by layers of earth compacted in place to a depth of at least 300 mm (12 inches) over pipe.~~
- I. ~~Full length of each section of pipe shall rest solidly upon pipe bed with recesses excavated to accommodate bells or joints. Do not lay pipes on wood blocking.~~
- J. ~~Tees, plugs, caps, bends, and hydrants installed on underground pipe shall be anchored. See paragraph PIPE SUPPORTS.~~
- K. ~~Close pipe openings with caps or plugs during installation. Tightly cover and protect equipment against dirt, water, and chemical, or mechanical injury. At completion of all work, thoroughly clean exposed materials and equipment.~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- ~~L. Good alignment shall be preserved in laying. The deflection at joints shall not exceed that recommended by the manufacturer.~~
- ~~M. Warning tape shall be continuously placed 300 mm (12 inches) below finish grade above buried water pipes, or at bottom of subbase where roadways exist, whichever is deeper with overall depth not exceeding 600 mm (24 inches). Detectable warning tape shall be locatable by the NCA staff from the finish grade above the pipe, utilizing existing locating equipment.~~
- ~~N. Trench excavation and compaction of backfill shall comply with the requirements of Section 31 20 00, EARTH MOVING.~~

3.5 DUCTILE IRON PIPE

- ~~A. Installing Pipe: Lay pipe in accordance with AWWA C600 with polyethylene encasement, if required, in accordance with AWWA C105. Provide a firm even bearing throughout the length of the pipe by tamping selected material at the sides of the pipe up to the spring line.~~
- ~~B. All pipe shall be sound and clean before laying. When laying is not in progress, the open ends of the pipe shall be closed by watertight plug or other approved means.~~
- ~~C. When cutting pipe is required, the cutting shall be done by an appropriate industry standard method, leaving a smooth cut at right angles to the axis of the pipe. Bevel cut ends of pipe to be used with push-on bell in order to conform to the manufactured spigot end. Cement lining shall be undamaged or perform cutting following manufacturer's recommendations for field cutting of pipe.~~
- ~~D. Jointing Ductile-Iron Pipe:~~
 - ~~1. Push-on joints shall be made in strict accordance with the manufacturer's instruction. Pipe shall be laid with bell ends looking ahead. A rubber gasket shall be inserted in the groove of the bell end of the pipe, and the joint surfaces cleaned and lubricated. The plain end of the pipe is to be aligned with the bell of the pipe to which it is joined, and pushed home following industry standard procedures or manufacturer's approved means.~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- ~~2. Mechanical Joints at Valves, Fittings: Install in strict accordance with AWWA C111. To assemble the joints in the field, thoroughly clean the joint surfaces and rubber gaskets with soapy water before tightening the bolts. Bolts shall be tightened to the specified torque. For new construction, all mechanical joints at valves and fittings shall be secured with an approved mechanical joint retainer glands suitable for the pipe.~~
- ~~3. Ball Joints: Install in strict accordance with the manufacturer's instructions. Where ball joint assemblies occur at the face of structures, the socket end shall be at the structure and ball end assembled to the socket.~~
- ~~4. Flanged joints shall be in accordance with AWWA C115. Flanged joints shall be fitted so that the contact faces bear uniformly on the gasket and then are made up with relatively uniform bolt stress.~~

~~3.6 PVC PIPE~~

- ~~A. PVC piping shall be installed in strict accordance with the manufacturer's instructions and AWWA C605. Place selected material and thoroughly compacted to one foot above the top of the pipe and thereafter back filled as specified in Section 31 20 00, EARTH MOVING.~~
- ~~B. Copper Tracer Wire: Copper tracer wire consisting of No. 14 AWG solid, single conductor, insulated copper wire shall be installed in the trench with all piping to permit location of the pipe with electronic detectors. The wire shall not be spiraled around the pipe nor taped to the pipe. Wire connections are to be made by stripping the insulation from the wire and soldering with rosin core solder. Solder joints shall be wrapped with rubber tape and electrical tape. At least every 300 m (984 feet), provide a 2.3 kg (5 pound) magnesium anode attached to the main tracer wire by solder. The solder joint shall be wrapped with rubber tape and with electrical tape. An anode shall be attached at the end of each line.~~

~~3.7 TRACER SYSTEM INSTALLATION~~

- ~~A. Install with all buried water main piping.~~
- ~~B. Begin and terminate system at all connections to existing mains.~~

Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft-AE Project No. 22-113

01/16/24

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- ~~C. Install wire continuously along the lower quadrant of the pipe. Do not install wire along the bottom of the pipe. Attach wire to the pipe at the midpoint of each pipe length; use 50 mm (2 inch) wide, 0.25 mm (10 mil) thickness polyethylene pressure sensitive tape.~~
- ~~D. Install splices only as authorized by the COR. Allow the COR to inspect all below-grade splices of tracer wire prior to backfill.~~
- ~~E. Install ground rods adjacent to connections to existing piping and at locations specified in the contract documents or as directed by the COR.~~
- ~~F. Bring two wires to the surface at each hydrant designated location within a valve box and cover and terminate with an accessible tracer wire termination.~~
- ~~G. Final inspection of the tracer system will be conducted at the completion of the project and prior to acceptance by the owner. Verify the electrical continuity of the system. Repair any discontinuities.~~

3.8 COPPER PIPE

- ~~A. Copper piping shall be installed in accordance with the Copper Development Association's Copper Tube Handbook and manufacturer's recommendations. Copper piping shall be bedded in 150 mm (6 inches) of sand and then back filled as specified in Section 31 20 00, EARTH MOVING.~~

3.9 PIPE SUPPORTS

- ~~A. All piping shall be properly and adequately supported. Hangers, supports, base elbows, tees, and concrete piers and pads shall be provided as indicated on the drawings. If the method of support is not indicated on the drawings, exposed piping shall be supported by hangers wherever the structure is suitable and adequate to carry the superimposed load. Supports shall be placed approximately 2.4 m (8 feet) on center and at each fitting.~~
- ~~B. Hangers shall be heavy malleable iron of the adjustable swivel type, split ring type, or the adjustable-swivel, pipe-roll type for horizontal piping and adjustable, wrought iron, clamp type for vertical~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

~~piping. Flat steel strap or chain hangers are not acceptable unless indicated on the drawings.~~

~~C. Hangers shall be attached to the structure, where possible, by beam clamps and approved concrete inserts set in the forms before concrete is poured. Where this method is impractical, anchor bolts with expanding lead shields, rawl drives, or malleable iron expansion shields will be permitted.~~

~~D. Where hangers cannot be used, provide pipe saddle supports with pipe column and floor flange.~~

3.10 RESTRAINED JOINTS

~~A. Sections of piping requiring restrained joints shall be constructed using pipe and fittings with restrained "locked-type" joints and the joints shall be capable of holding against withdrawal for line pressures 50 percent above the normal working pressure but not less than 1380 kPa (200 psi). The pipe and fittings shall be restrained push-on joints or restrained mechanical joints.~~

~~B. The minimum number of restrained joints required for resisting force at fittings and changes in direction of pipe shall be determined from the length of retained pipe on each side of fittings and changes in direction necessary to develop adequate resisting friction with the soil. Restrained pipe length shall be as shown on the drawings.~~

~~C. Restrained joint assemblies with ductile iron mechanical joint pipe shall be as specified herein in paragraph MECHANICAL JOINT RETAINER GLANDS or approved equal.~~

~~D. Thrust blocks shall be required, unless otherwise noted.~~

~~E. Where ductile iron pipe manufactured with restrained joints is utilized, all restrained joints shall be fully extended and engaged prior to back filling the trench and pressurizing the pipe.~~

~~F. Ductile iron mechanical joint fittings used with PVC pipe shall be restrained with the specified Mechanical Joint Restrainer Gland, or approved equal.~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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~~3.11 PIPE SEPARATION~~

~~A. Horizontal Separation-Water Mains and Sewers:~~

- ~~1. Water mains shall be located at least 3 m (10 feet) horizontally from any proposed drain, storm sewer, sanitary, or sewer service connection.~~
- ~~2. Water mains may be located closer than 3 m (10 feet) to a sewer line when:~~
 - ~~a. Local conditions prevent a lateral separation of 3 m (10 feet); and~~
 - ~~b. The water main invert is at least 457 mm (18 inches) above the crown of the sewer; and~~
 - ~~c. The water main is either in a separate trench or in the same trench on an undisturbed earth shelf located one side of the sewer.~~
- ~~3. When it is impossible to meet (1) or (2) above, both the water main and drain or sewer shall be constructed of mechanical joint ductile iron pipe. Ductile iron pipe shall comply with the requirements listed in this specification section. The drain or sewer shall be pressure tested to the maximum expected surcharge head before back filling.~~

~~B. Vertical Separation-Water Mains and Sewers:~~

- ~~1. A water main shall be separated from a sewer so that its invert is a minimum of 457 mm (18 inches) above the crown of the drain or sewer whenever water mains cross storm sewers, sanitary sewers, or sewer service connections. The vertical separation shall be maintained for that portion of the water main located within 3 m (10 feet) horizontally of any sewer or drain crossed. A length of water main pipe shall be centered over the sewer to be crossed with joints equidistant from the sewer or drain.~~
- ~~2. Both the water main and sewer shall be constructed of slip-on or mechanical joint ductile iron pipe or PVC pipe equivalent to water main standards of construction when:~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- ~~a. It is impossible to obtain the proper vertical separations described in (1) above; or~~
- ~~b. The water main passes under a sewer or drain.~~
- ~~3. A vertical separation of 457 mm (18 inches) between the invert of the sewer or drain and the crown of the water main shall be maintained where a water main crosses under a sewer. Support the sewer or drain lines to prevent settling and breaking the water main.~~
- ~~4. Construction shall extend on each side of the crossing until the perpendicular distance from the water main to the sewer or drain line is at least 3 m (10 feet).~~

~~3.12 SETTING OF VALVES AND BOXES~~

- ~~A. Provide a surface concrete pad 457 by 457 by 150 mm (18 by 18 by 6 inches) to protect valve box when valve is not located below pavement.~~
- ~~B. Clean valve and curb stops interior before installation.~~
- ~~C. Set valve and curb stop box cover flush with finished grade.~~
- ~~D. Set curb stop box and cover for access to identification wire and/or detectable warning tape with a 300 by 300 by 75 mm (12 by 12 by 3 inches) at approximately the depth of the warning tape and bring the tape and/or identification wire into the box and coil extra length sufficient to allow the tape or wire to be uncoiled and extended 1500 mm (5 feet) above finish grade at the location.~~
- ~~E. Valves shall be installed plumb and level and in accordance with manufacturer's recommendations.~~

~~3.13 SETTING OF FIRE HYDRANTS~~

- ~~A. Set center of each hydrant not less than 600 mm (2 feet) nor more than 1829 mm (6 feet) back of edge of road or face of curb. Fire apparatus connection shall face road with center of nozzle 457 mm (18 inches) above finished grade. Set barrel flange not more than 50 mm (2 inches) above finished grade.~~
- ~~B. Set each hydrant on a slab of stone or concrete not less than 100 mm (4 inches) thick and 381 mm (15 inches) square. The service line to the~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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~~hydrant, between the tee and the shoe of the hydrant, shall be fully restrained.~~

~~C. Set bases in not less than 0.4 cubic meter (1/2 cubic yard) of crushed rock or gravel placed entirely below hydrant drainage device.~~

~~D. Clean interiors of hydrants of all foreign matter before installation.~~

3.14 PIPE SLEEVES

~~A. Install where water lines pass through retaining walls, building foundations, and floors. Seal with modular mechanical type link seal. Install piping so that no joint occurs within a sleeve. Split sleeves may be installed where existing lines pass through new construction.~~

3.15 HYDROSTATIC TESTING

~~A. Hydrostatic testing of the system shall occur prior to disinfecting the system.~~

~~B. After new system is installed, except for connections to existing system and building, backfill at least 300 mm (12 inches) above pipe barrel, leaving joints exposed. The depth of the backfill shall be adequate to prevent the horizontal and vertical movement of the pipe during testing.~~

~~C. Prior to pressurizing the line, all joint restraints shall be completely installed and inspected.~~

~~D. If the system is tested in sections, and at the temporary caps at connections to the existing system and buildings, provide and install all required temporary thrust restraints required to safely conduct the test.~~

~~E. Install corporation stops in the line as required to purge the air out of the system. At the completion of the test, all corporation stops shall be capped.~~

~~F. Perform pressure and leakage tests for the new system for 2 hours to 1380 kPa (200 psi). Leakage shall not exceed the following requirements.~~

~~1. Copper Tubing: No leaks.~~

~~2. Ductile Iron Pipe: AWWA C600. Provide to COR office.~~

~~3. Polyvinyl Chloride (PVC) AWWA C605. Provide to COR office.~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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~~3.16 FLUSHING AND DISINFECTING~~

- ~~A. Flush and disinfect new water lines in accordance with AWWA C651.~~
- ~~B. Initial flushing shall obtain a minimum velocity in the main of 0.75 m/s (2.5 f/s) at 276 kPa (40 psi) residual pressure in water main. The duration of the flushing shall be adequate to remove all particles from the line.~~

Pipe Diameter		Flow Required to Produce 76 cm/sec (2.5 ft/sec) (approx.) Velocity in Main		Number of Hydrant Outlets			
				Size of Tap, mm (in.)			
				25(1)	38(1 1/2)	51(2)	64(2 1/2)
mm	(In)	L/sec	(gpm)	Number of taps on pipe			
100	(4)	6.3	(100)	1	--	--	1
150	(6)	12.6	(200)	--	1	--	1
200	(8)	25.2	(400)	--	2	1	1
250	(10)	37.9	(600)	--	3	2	1
300	(12)	56.8	(900)	--	--	3	2
400	(16)	100.9	(1600)	--	--	4	2

~~Note: The backflow preventers shall not be in place during the flushing.~~

- ~~C. Provide the water source for filling, flushing, and disinfecting the lines; only potable water shall be used. Provide all required temporary pumps, storage facilities required to complete the specified flushing, and disinfection operations.~~
- ~~D. Dispose of all water used to flush and disinfect the system in accordance with all governing rules and regulations. The discharge water shall not be allowed to create a nuisance for activities occurring on or adjacent to the site.~~
- ~~E. The bacteriological test specified in AWWA C651 shall be performed by a laboratory approved by the Health Department of the State. The cost of sampling, transportation, and testing shall be the responsibility of the Contractor.~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

~~F. Re-disinfection and bacteriological testing of failed sections of the system shall be the sole responsibility of the Contractor.~~

~~G. Before backflow preventers are installed, all upstream piping shall be thoroughly flushed.~~

~~3.17 BACKFLOW PREVENTOR TESTING~~

~~A. All backflow preventers shall be installed, tested, and certified for proper operation prior to being placed in operation.~~

~~B. Original copies of the certification shall be submitted to the COR.~~

~~3.18 STARTUP AND TESTING~~

~~A. Make tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.~~

~~B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.~~

~~C. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.~~

~~3.19 COMMISSIONING~~

~~A. Provide commissioning documentation in accordance with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.~~

~~B. Components provided under this section of the specification will be tested as part of a larger system.~~

~~3.20 DEMONSTRATION AND TRAINING~~

~~A. Provide services of manufacturer's technical representative for four hours to instruct each VA personnel responsible in the operation and maintenance of units.~~

~~B. Submit training plans and instructor qualifications in accordance with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.~~

~~--- E N D ---~~

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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~~SECTION 33 30 00~~
~~SANITARY SEWERAGE UTILITIES~~

~~PART 1 - GENERAL~~

~~1.1 DESCRIPTION~~

~~A. Outside, underground sanitary sewer system, complete, ready for operation, including all gravity flow lines manholes, cleanouts, frames, covers, structures, appurtenances, and connections to new building and structure, service lines, existing sanitary sewer lines, and existing sanitary structures, and all other incidentals.~~

~~1.2 RELATED WORK~~

~~A. Section 01 00 02, GENERAL REQUIREMENTS (Minor NCA Projects).~~
~~B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.~~
~~C. Section 01 42 19, REFERENCE STANDARDS.~~
~~D. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS.~~
~~E. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.~~
~~F. Section 03 30 53, (SHORT FORM) CAST-IN-PLACE CONCRETE.~~
~~G. Section 05 50 00, METAL FABRICATIONS: Fabrication of Steel Ladders.~~
~~H. Section 31 20 00, EARTH MOVING: Excavation, Trench Widths, Pipe Bedding, Backfill, Shoring, Sheeting, Bracing.~~
~~I. Section 32 90 00, PLANTING: Seeding, Topsoil.~~
~~J. Section 33 10 00, WATER UTILITIES.~~

~~1.3 APPLICABLE PUBLICATIONS~~

~~A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.~~
~~B. American Society for Testing and Materials (ASTM):~~
~~A48/A48M-2003 (R2012)...Standard Specification for Gray Iron Castings~~
~~A536-1984 (R2014).....Standard Specification for Ductile Iron Castings~~
~~A615/A615M-2015a.....Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement~~

~~Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2~~

~~Bancroft Architects + Engineers~~

~~A746-2009 (R2014).....Standard Specification for Ductile Iron Gravity
Sewer Pipe~~

~~C76-2015a.....Standard Specification for Reinforced Concrete
Culvert, Storm Drain, and Sewer Pipe~~

~~C139-2014.....Standard Specification for Concrete Masonry
Units for Construction of Catch Basins and
Manholes~~

~~C150/C150M-2015.....Standard Specification for Portland Cement~~

~~C478-2015.....Standard Specification for Circular Precast
Reinforced Concrete Manhole Sections~~

~~C857-2014.....Standard Practice for Minimum Structural Design
Loading for Underground Precast Concrete
Utility Structures~~

~~C990-2009 (R2014).....Standard Specification for Joints for Concrete
Pipe, Manholes, and Precast Box Sections Using
Preformed Flexible Joint Sealants~~

~~D698-2012e2.....Standard Test Methods for Laboratory Compaction
Characteristics of Soil Using Standard Effort
(12,400 ft-lbf/ft³ (600 kN-m/m³))~~

~~D2321-2014e1.....Standard Practice for Underground Installation
of Thermoplastic Pipes for Sewers and Other
Gravity-Flow Applications~~

~~D2412-2011.....Standard Test Method for Determination of
External Loading Characteristics of Plastic
Pipe by Parallel-Plate Loading~~

~~D3034-2014a.....Standard Specification for Type PSM Poly (Vinyl
Chloride) (PVC) Sewer Pipe and Fittings~~

~~D3212-2007 (R2013).....Standard Specification for Joints for Drain and
Sewer Plastic Pipes Using Flexible Elastomeric
Seals~~

~~D3261-2012e1.....Standard Specification for Butt Heat Fusion
Polyethylene (PE) Plastic Fittings for
Polyethylene (PE) Plastic Pipe and Tubing~~

~~Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft AE Project No. 22-113~~

~~33-30-00-2~~

~~01/16/24~~

~~Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2~~

~~Bancroft Architects + Engineers~~

~~D3350-2014.....~~	~~Standard Specification for Polyethylene Plastics Pipe and Fittings Materials~~
~~D4101-2014.....~~	~~Standard Specification for Polypropylene Injection and Extrusion Materials~~
~~F477-2014.....~~	~~Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe~~
~~F679-2015.....~~	~~Standard Specification for Poly (Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings~~
~~F714-2013.....~~	~~Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter~~
~~F794-2003 (R2014).....~~	~~Standard Specification for Poly (Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter~~
~~F894-2013.....~~	~~Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe~~
~~F949-2015.....~~	~~Standard Specification for Poly (Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings~~
~~C. American Water Works Association (AWWA):~~	
~~C110-2012.....~~	~~Ductile-Iron and Gray-Iron Fittings~~
~~C153-2011.....~~	~~Ductile-Iron Compact Fittings~~
~~C508-2009.....~~	~~Swing Check Valves for Waterworks Service, 2 inches Through 24 inches (50 mm Through 600 mm) NPS~~
~~C509-2009.....~~	~~Resilient-Seated Gate Valves for Water Supply Service~~
~~C512-2015.....~~	~~Air Release, Air/Vacuum, and Combination Air Valves for Water and Wastewater Service~~
~~C515-2009.....~~	~~Reduced-Wall, Resilient-Seated Gate Valves For Water Supply Service~~

~~Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2~~

~~Bancroft Architects + Engineers~~

- ~~C550-2013.....Protective Interior Coatings for Valves and Hydrants~~
- ~~C605-2013.....Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVC0) Pressure Pipe and Fittings~~
- ~~C900-2007.....Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 100 mm Through 300 mm (4 inches Through 12 inches) for Water Transmission and Distribution~~
- ~~C905-2010.....Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 350 mm through 1,200 mm (14 Inches through 48 Inches), for Water Transmission and Distribution~~
- ~~C906-2015.....Polyethylene (PE) Pressure Pipe and Fittings, 100 mm through 1650 mm (4 Inches through 65 Inches), for Waterworks~~

~~D. Uni-Bell PVC Pipe Association:~~

- ~~Uni-B-6-1998.....Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe~~

~~1.4 SUBMITTALS~~

- ~~A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.~~
- ~~B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 33 30 00, SANITARY SEWERAGE UTILITIES", with applicable paragraph identification.~~
- ~~C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.~~
- ~~D. Submit the following as one package:~~
- ~~1. Pipe, Fittings, and, Appurtenances.~~
 - ~~2. Jointing Material.~~

~~Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft AE Project No. 22-113~~

~~33 30 00-4~~

~~01/16/24~~

~~Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2~~

~~Bancroft Architects + Engineers~~

- ~~3. Manhole and Structure Material.~~
- ~~4. Frames and Covers.~~
- ~~5. Steps and Ladders.~~
- ~~E. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:~~
 - ~~1. Include complete list indicating all components of the systems.~~
 - ~~2. Include complete diagrams of the internal wiring for each item of equipment.~~
 - ~~3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.~~
- ~~F. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.~~
- ~~G. Submit training plans and instructor qualifications in accordance with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.~~

~~1.5 QUALITY ASSURANCE~~

- ~~A. Products Criteria:~~
 - ~~1. Multiple Units: When two or more units of the same type or class of materials or equipment are required, these units shall be products of one manufacturer.~~
 - ~~2. Nameplates: Nameplate bearing manufacturer's name, or identifiable trademark, including model number, securely affixed in a conspicuous place on equipment, or name or trademark, including model number cast integrally with equipment, stamped, or otherwise permanently marked on each item of equipment.~~
- ~~B. Comply with the rules and regulations of the Public Utility having jurisdiction over the connection, extension, and modification to Public Sanitary Sewer lines and Public Utility Systems as applicable.~~

~~Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft AE Project No. 22-113~~

~~33-30-00-5~~

~~01/16/24~~

~~Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2~~

~~Bancroft Architects + Engineers~~

~~1.6 AS-BUILT DOCUMENTATION~~

- ~~A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.~~
- ~~B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.~~
- ~~C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them in Auto-CAD version 2024 provided on CD or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement.~~
- ~~D. Certification documentation shall be provided to COR 10 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and certification that all results of tests were within limits specified.~~

~~Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2~~

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PART 2 - PRODUCTS

2.1 PIPING

~~A. Gravity Flow Lines (Pipe and Fittings):~~

~~1. Polyvinyl Chloride (PVC):~~

- ~~a. Pipe and Fittings, 100 mm to 381 mm (4 inches to 15 inches) in diameter, shall conform to ASTM D3034, Type PSM, SDR 26. Pipe and fittings shall have elastomeric gasket joints providing a watertight seal when tested in accordance with ASTM D3212. Gaskets shall conform to ASTM F477. Solvent welded joints are prohibited.~~
- ~~b. Pipe and fittings, 450 mm to 900 mm (18 inches to 36 inches) in diameter, shall be solid wall or have a corrugated or ribbed exterior profile and a smooth interior. Pipe shall conform to the following:~~
 - ~~1) Pipe and fittings shall conform to ASTM F949 corrugated sewer pipe with a smooth interior. The corrugated outer wall shall be fused to the smooth innerwall at the corrugation valley. Pipe and fitting shall have a smooth bell, elastomeric joints conforming to ASTM D3212, and shall have a minimum pipe stiffness of 345 kPa (50 psi) at 5 percent deflection when tested in accordance with ASTM D2412. Corrugation shall be perpendicular to the axis of the pipe to allow gaskets to be installed on field cut sections of pipe without the requirement for special fittings.~~
 - ~~2) Ribbed wall PVC pipe and fittings shall conform to ASTM F794 ribbed sewer pipe with smooth interior pipe. Fittings shall have a smooth bell, elastomeric joints conforming to ASTM D3212, and shall have a minimum pipe stiffness of 320 kPa (46 psi) when tested in accordance with ASTM D 2412 at 5 percent vertical deflection. Joints shall not leak at 7.6 m (25 feet) of head under 5 percent deflection.~~
 - ~~3) Solid wall pipe and fittings shall conform to ASTM F679, SDR 26 pipe. Fittings shall have gaskets conforming to ASTM F477~~

~~Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft AE Project No. 22-113~~

~~33-30-00-7~~

01/16/24

~~Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2~~

~~Bancroft Architects + Engineers~~

~~and shall be able to withstand a hydrostatic pressure of 345 kPa (50 psi).~~

- ~~2. High density polyethylene (HDPE) pipe and fittings 450 mm to 900 mm (18 inches to 36 inches) shall conform to ASTM F894. Pipe and fittings shall have a smooth interwall and profile exterior, and be Class 63 Joints shall be water tight elastomeric gaskets in accordance with ASTM D3212, or thermal welded joints.~~

~~B. Pressure (Force) Lines (Pipe and Fittings):~~

- ~~1. All pipe and fittings used in the construction of force mains shall be rated for a minimum of 1035 kPa (150 psi).~~
- ~~2. Polyvinyl Chloride (PVC): PVC pipe 100 mm to 300 mm (4 inches to 12 inches) shall conform to AWWA C900. PVC pipe greater than 300 mm (12 inches) shall conform to AWWA C905. Fittings for PVC pipe shall be ductile iron conforming to AWWA C153 or AWWA C110.~~
- ~~3. High Density Polyethylene (HDPE) pipe and fittings shall be manufactured from PE 3608, high density, extra high molecular weight polyethylene meeting the requirements of ASTM D3350. Pipe shall be manufactured in accordance with ASTM F714, and shall be Class 160 (DR 11). Molded fittings shall be manufactured in accordance with ASTM D3261 and subject to the test required under ASTM D3261. Fabricated fittings shall be made by heat fusion jointing of machined shapes cut from pipe, sheet stock, or molded fittings. Molded and fabricated fittings shall be rated for a minimum working pressure equivalent to the pipe. Joints shall be heat fusion butt joints, flange adapters, or mechanical couplings.~~
 - ~~a. Flange adapters shall have adequate through-bore length to be clamped in a butt fusion jointing machine without the use of a stub-end holder. The sealing surface of the flanged shall be machined with a series of V-shaped grooves to restrain the gasket against blow out. Back-up rings and flange bolts shall be rated equal to or greater than the mating pipe. All flange adapters shall be equipped with a stainless steel internal pipe stiffener.~~
 - ~~b. Mechanical couplings shall be sleeve style, restrained coupling.~~

~~Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2~~

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~~2.2 JOINTING MATERIAL~~

~~A. Gravity Flow Lines:~~

- ~~1. Polyvinyl Chloride (PVC) Pipe (Gravity Use): Joints, ASTM D3212.
Elastomeric gasket, ASTM F477.~~
- ~~2. High Density Polyethylene (HDPE) pipe and fitting joints, ASTM
D3212, elastomeric gaskets, ASTM F477.~~

~~B. Pressure (Force) Main:~~

- ~~1. Polyvinyl Chloride (PVC) Pipe (Pressure Use): Conform to AWWA C900.
a. Push-on joints shall conform to AWWA C900 and AWWA C905.
b. Push-on gaskets for pipe, ASTM F477.
c. Restrained joints shall comply with the following:
1) Push-on bell and spigot joints shall be retained with
retaining rings and thrust rods. The rings shall be ductile
iron conforming to ASTM A536.~~
- ~~2. High Density Polyethylene (HDPE) pipe and fittings shall be fusion
butt welded, flanged, or mechanical couplings as recommended by the
manufacturer. Restrained joints shall be limited to fusion welded
and flanged.~~

~~2.3 MANHOLES AND VAULTS~~

~~A. Manholes and vaults shall be constructed of precast concrete segmental
blocks, precast reinforced concrete rings, precast reinforced sections,
or cast-in-place concrete. The manholes and vaults shall be in
accordance with State Department of Transportation or State Roads
Commission standard details, and the following:~~

- ~~1. Precast Concrete Segmental Blocks: Blocks shall conform to ASTM C139
and shall not be less than 150 mm (6 inches) thick for manholes to a
depth of 3.6 m (12 feet); not less than 200 mm (8 inches) thick for
manholes deeper than 3.6m (12 feet) deep. Blocks shall be not less
than 200 mm (8 inches) in length. Blocks shall be shaped so that
joints seal and bond effectively with cement mortar. Cover structure
interior and exterior with 15 mm (1/2 inch) of cement mortar applied
with a trowel and finished to an even glazed surface.~~

~~Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2~~

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- ~~2. Precast Reinforced Concrete Rings: Rings or sections shall have an inside diameter as indicated on the drawings, and shall be not less than 1219 mm (48 inches) in diameter. Wall thickness shall conform to requirements of ASTM C478, except that lengths of the sections may be shorter as conditions require. Tops shall conform to ASTM C478. Top section shall be eccentric cone type. Steps on inside wall shall be in the same plane from bottom of structure to manhole cover.~~
- ~~3. Precast Reinforced Concrete Manhole Risers and Tops: Design, material and installation shall conform to requirements of ASTM C478. Top sections shall be eccentric. Steps on inside wall shall be in the same plane from bottom of structure to manhole cover.~~
- ~~4. Flat top manhole tops shall be reinforced concrete as detailed on the drawings.~~
- ~~5. Vaults: Reinforced concrete, as indicated on the plans, or precast reinforced concrete. Concrete for precast sections shall have a minimum compressive strength of 35 MPa (5,000 psi) at 28 days, ASTM A615/A615M, Grade 60 reinforcing steel, rated for AASHTO HS20-44 loading with 30 percent impact, and conform to ASTM C857.~~
- ~~6. Mortar:~~
 - ~~a. Precast Concrete Segmental Block Structures: By volume, 1 part of Portland cement, 1/4 part lime hydrate, and 3 parts sand.~~
 - ~~b. Precast Reinforced Concrete Ring and Riser Structures: By volume, 1 part of Portland cement and 2 parts sand. Water in mixture shall produce a stiff, workable mortar, but shall not exceed 21 L (5-1/2 gallons) per sack of cement.~~
- ~~7. Flexible sealing compound shall be packaged in extruded preformed shape, sized to completely fill the joint between precast sections, and form permanently flexible watertight seal. The sealing compound shall be non-shrink and meet ASTM C990.~~
- ~~8. Frames and covers shall be gray cast iron conforming to ASTM A48/A48M. The frame and cover shall be rated for AASHTO HS20-44 loading, have a studded pattern on the cover, and the words~~

~~Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2~~

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- ~~"sanitary sewer". The studs and the lettering shall be raised 8 mm (5/16 inch). The cover shall be a minimum of 600 mm (24 inches) in diameter and shall have four 20 mm (3/4 inch) vent holes and two lifting slots. The bearing surface of the frame and cover shall be machine finished. The cover shall fit firmly on the frame without movement when subject to traffic.~~
- ~~9. Manhole steps shall be polypropylene plastic coated on a No. 4 deformed rebar conforming to ASTM C478, Polypropylene shall conform to ASTM D4101. Steps shall be a minimum of 400 mm (16 inches) wide and project a minimum of 175 mm (7 inches) away from the wall. The top surface of the step shall have a studded non-slip surface. Steps shall be placed at 300 mm (12 inch) centers.~~
- ~~10. Ladders, brackets and hardware shall be constructed of welded aluminum, rails shall be 10 mm (3/8 inch) by 65 mm (2-1/2 inches) spaced a minimum of 400 mm (16 inches) apart. Rungs shall be 35 mm (1-3/8 inches) in diameter and have a non-slip surface. Standoffs shall offset the ladder 175 mm (7 inches) from the wall. The ladder assembly shall be rated for a minimum of 2200 N (500 pounds).~~

~~2.4 CONCRETE~~

- ~~A. Concrete shall have a minimum compressive strength of 21 MPa (3000 psi) at 28 days. The cement shall be Type III conforming to ASTM C150/C150M. Concrete shall conform with the provisions of Division 03, CONCRETE.~~

~~2.5 REINFORCING STEEL~~

- ~~A. Reinforcing steel shall be deformed bars, ASTM A615/A615M, Grade 60 unless otherwise noted.~~

~~2.6 CONCRETE PROTECTIVE COATING~~

- ~~A. Concrete coating for the interior of wet wells shall consist of an epoxy blended filler sealer, and a cross linked epoxy phenolic cured, resistant protective coating.~~

~~2.7 GATE VALVES~~

- ~~A. AWWA C509, resilient seated gate valves rated for 1380 kPa (200 psi) WSP, reduced-wall resilient seated gates valves may be supplied in~~

~~Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2~~

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~~accordance with AWWA C515. Asbestos packing is prohibited. The interior and exterior of the valve shall be epoxy coated for AWWA C550.~~

~~B. Operation:~~

~~C. Shall turn counterclockwise to open.~~

~~D. Underground: 50 mm (2 inch) nut for socket wrench operation.~~

~~E. Above Ground and In Pits: Handwheels.~~

~~F. Joints: End of valve shall accommodate, or be adapted to, pipe furnished.~~

~~2.8 VALVE BOXES~~

~~A. Cast iron extension box with screw or slide-type adjustment and flared base. Minimum thickness of metal shall be 5 mm (3/16 inch). Box shall be of such length as will be adapted, without full extension, to depth of cover required over pipe at valve location. The least diameter of the shaft of the box shall be 133 mm (5-1/4 inches). Cast iron box shall have a heavy coat of bituminous paint.~~

~~B. Cast the word "SEWER" on the cover.~~

~~C. Provide two "T" handle socket wrenches, of 18 mm (5/8 inch) round stock long enough to extend 600 mm (2 feet) above top of deepest valve box.~~

~~2.9 CHECK VALVES~~

~~A. Check valves shall be swing-check valves conforming to AWWA C508. The interior and exterior of the valve shall be epoxy coated per AWWA C550. The check valve shall be rated for minimum of 861 kPa (125 psi) working pressure.~~

~~2.10 OIL AND GREASE INTERCEPTOR AND GREASE REMOVAL PIT~~

~~A. Shall be constructed of reinforced precast concrete or cast-in-place concrete of the shape and configuration indicated on the plans. Precast vaults shall be constructed in accordance with ASTM C857 and be rated for AASHTO HS20-44 loading. The concrete shall have a minimum compressive strength of 35 MPa (5,000 psi) at 28 days, and reinforcement shall comply with ASTM A615/A615M, Grade 60. Access to the trap shall be through 600 mm (24 inches) diameter manhole frame and cover or through hinged aluminum access manways.~~

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- ~~B. Baffles shall be constructed of 6 mm (1/4 inch) mild carbon steel with 6 mm (1/4 inch) thermoplastic coating.~~

~~2.11 AIR RELEASE VALVE~~

- ~~A. Valves shall be combination air release and vacuum valve with a single body. The valves shall be rated for 1035 kPa (150 psi) working pressure, and conform to AWWA C512. Valve shall be provided with threaded connections, and be mounted on a full opening ball valve which shall isolate the valve from the system.~~

~~2.12 CLEANOUT FRAMES AND COVERS~~

- ~~A. Frames and covers shall be gray iron casting conforming to ASTM A48/A48M. The frame and cover shall be rated for AASHTO HS20-44 wheel loading, have a studded pattern on its cover, vent holes, and lifting slots. The cover shall fit firmly on the frame without movement when subject to vehicular traffic. The word "SEWER" shall be cast on the cover.~~

~~2.13 WARNING TAPE~~

- ~~A. Standard, 0.10 mm (4 mils) polyethylene 75 mm (3 inch) wide tape detectable type, green with black letters and imprinted with "CAUTION BURIED SEWER LINE BELOW".~~

~~PART 3 - EXECUTION~~

~~3.1 INSTALLATION~~

- ~~A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.~~

~~3.2 BUILDING SERVICE LINES~~

- ~~A. Install sanitary sewer service lines to point of connection within approximately 1500 mm (5 feet) outside of buildings where service is required and make connections. Coordinate the invert and location of the service line with the contractor installing the building lines.~~
- ~~B. Connections of service line to building piping shall be made after the new sanitary sewer system has been constructed, tested, and accepted~~

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~~for operation by the COR. Install all temporary caps or plugs required for testing.~~

- ~~C. When building services have not been installed at the time when the sanitary sewer system is complete, provide temporary plugs or caps at the ends of all service lines. Mark the location and depth of the service lines with continuous warning tape placed 300 mm (12 inches) above service lines.~~

~~3.3 ABANDONED MANHOLES STRUCTURES AND PIPING~~

- ~~A. Manholes and Structures Outside of Building Areas: Remove frame and cover, cut, and remove the top to an elevation of 600 mm (2 feet) below finished grade. Fill the remaining portion with compacted gravel or crushed rock or concrete.~~
- ~~B. Manholes and Structures within Building Areas: Remove frame and cover and remove the entire structure and the base.~~
- ~~C. Piping under and within 1500 mm (5 feet) of building areas shall be completely removed.~~
- ~~D. Piping outside of building areas shall have all ends of the piping at the limit of the abandonment and within structures and manholes, plugged with concrete, and abandoned in-place.~~
- ~~E. Comply with all OSHA confined space requirements while working within existing manholes and structures.~~
- ~~F. When the limit of the abandonment terminates in an existing manhole to remain, the flow line in the bench of the manhole to the abandoned line shall be filled with concrete and shaped to maintain the flowline of the lines to remain.~~

~~3.4 REGRADING~~

- ~~A. Raise or lower existing manholes and structures frames and covers, cleanout frames and covers and valve boxes in regraded areas to finish grade. Carefully remove, clean, and salvage cast iron frames and covers. Adjust the elevation of the top of the manhole or structure as detailed on the drawings. Adjust the elevation of the cleanout pipe riser, and reinstall the cap or plug. Reset cast iron frame and cover,~~

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~~grouting below and around the frame. Install concrete collar around reset frame and cover as specified for new construction.~~

- ~~B. During periods when work is progressing on adjusting manholes or structures cover elevations, install a temporary cover above the bench of the structure or manhole. The temporary cover shall be installed above the high flow elevation within the structure, and shall prevent debris from entering the wastewater stream.~~
- ~~C. Comply with all OSHA confined space requirements when working within existing structures.~~

~~3.5 CONNECTIONS TO EXISTING VA OWNED MANHOLES~~

- ~~A. During construction of new connections to existing manholes, maintain continued sanitary sewer service to all buildings and users upstream. Provide, install, and maintain all pumping, conveyance system, dams, weirs, etc. required to maintain the continuous flow of sewage. All temporary measures required to meet this requirement shall be subject to the review of the COR.~~
- ~~B. Core existing structure, install pipe at the design invert. Install an elastomeric gasket around the pipe, and grout the interstitial space between the pipe and the core.~~
- ~~C. The bench of the manhole shall be cleaned and reshaped to provide a smooth flowline for all pipes connected to the manhole.~~
- ~~D. Connections and alterations to existing manholes shall be constructed so that finished work conforms as nearly as practicable to the applicable requirements specified for new manholes, including concrete and masonry work, cutting and shaping.~~

~~3.6 PIPE SEPARATION~~

- ~~A. Horizontal Separation - Water Mains and Sewers:~~
 - ~~1. Existing and proposed water mains shall be at least 3 meters (10 feet) horizontally from any proposed gravity flow and pressure (force main) sanitary sewer or sewer service connection.~~
 - ~~2. Gravity flow mains and pressure (force) mains may be located closer than 3 meters (10 feet) but not closer than 1.8 m (6 feet) to a water main when:~~

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Fargo, North Dakota 58102-2417
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- a. ~~Local conditions prevent a lateral separation of ten feet; and~~
 - b. ~~The water main invert is at least 450 mm (18 inches) above the crown of the gravity sewer or 600 mm (24 inches) above the crown of the pressure (force) main; and~~
 - c. ~~The water main is in a separate trench separated by undisturbed earth.~~
3. ~~When it is impossible to meet (1) or (2) above, both the water main and sanitary sewer main shall be constructed of push-on or mechanical joint ductile iron pipe. The pipe for the sanitary sewer main shall comply with the specifications for pressure (force) mains, and the water main material shall comply with Section 33 10 00, WATER UTILITIES. The sewer shall be pressure tested as specified for pressure (force) mains before backfilling.~~
- B. ~~Vertical Separation - Water Mains and Sewers at Crossings:~~
1. ~~Water mains shall be separated from sewer mains so that the invert of the water main is a minimum of 600 mm (24 inches) above the crown of gravity flow sewer or 1219 mm (48 inches) above the crown of pressure (force) mains. The vertical separation shall be maintained within 3 meters (10 feet) horizontally of the sewer and water crossing. When these vertical separations are met, no additional protection is required.~~
 2. ~~In no case shall pressure (force) sanitary main cross above, or within 600 mm (24 inches) of water lines.~~
 3. ~~When it is impossible to meet (1) above, the gravity flow sewer may be installed 450 mm (18 inches) above or 300 mm (12 inches) below the water main, provided that both the water main and sewer shall be constructed of push-on or mechanical ductile pipe. Pressure (Force) sewers may be installed 600 mm (24 inches) below the water line provided both the water line and sewer line are constructed of ductile iron pipe. The pipe for the sewer shall conform to the requirements for pressure sewers specified herein. Piping for the water main shall conform to Section 33 10 00, WATER UTILITIES.~~

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EHRM Infrastructure Upgrades-Tier 2~~

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- ~~4. The required vertical separation between the sewer and the water main shall extend on each side of the crossing until the perpendicular distance from the water main to the sewer line is at least 3 meters (10 feet).~~

~~3.7 GENERAL PIPING INSTALLATION~~

- ~~A. Lay pipes true to line and grade. Gravity flow sewer shall be laid with bells facing upgrade. Pressure (force) mains shall have the bells facing the direction of flow.~~
- ~~B. Do not lay pipe on unstable material, in wet trench, or when trench and weather conditions are unsuitable for the work.~~
- ~~C. Support pipe on compacted bedding material. Excavate bell holes only large enough to properly make the joint.~~
- ~~D. Inspect pipes and fittings, for defects before installation. Defective materials shall be plainly marked and removed from the site. Cut pipe shall have smooth regular ends at right angles to axis of pipe.~~
- ~~E. Clean interior of all pipe thoroughly before installation. When work is not in progress, open ends of pipe shall be closed securely to prevent entrance of storm water, dirt, or other substances.~~
- ~~F. Lower pipe into trench carefully and bring to proper line, grade, and joint. After jointing, interior of each pipe shall be thoroughly wiped or swabbed to remove any dirt, trash, and excess jointing materials.~~
- ~~G. Do not lay sewer pipe in same trench with another pipe or other utility. Sanitary sewers shall cross at least 600 mm (2 feet) below water lines.~~
- ~~H. Do not walk on pipe in trenches until covered by layers of bedding or backfill material to a depth of 300 mm (12 inches) over the crown of the pipe.~~
- ~~I. Warning tape shall be continuously placed 300 mm (12 inches) above sewer pipe.~~
- ~~J. Install gravity sewer line in accordance with the provisions of these specifications and the following standards:~~
- ~~1. Polyvinyl Chloride (PVC) Piping: ASTM D2321.~~

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- ~~2. High Density Polyethylene (HDPE) Piping: Comply with ASTM D2321 and manufacturer's recommendations with gasketed joints.~~

~~K. Installation of Pressure (Force) Mains~~

- ~~1. Sections of piping listed on the drawings shall be fully restrained using approved joint restraint devices. Joint restraint devices shall be installed in accordance with the manufacturer's recommendations. For devices with twist of nuts, the twist of nuts shall be placed on top of the fitting for the Engineer's inspection. Torque test all bolts, set screws, identified by the COR.~~
- ~~2. Thrust blocks are prohibited.~~
- ~~3. Install pressure (force) mains in accordance with the provisions of these specifications and the following standards:~~
 - ~~a. Polyvinyl Chloride (PVC) Piping: AWWA C605.~~
 - ~~b. High Density Polyethylene (HDPE) Piping: Per manufacturer's recommendations.~~

~~3.8 MANHOLES AND VAULTS~~

~~A. General:~~

- ~~1. Circular Structures:~~
 - ~~a. Precast concrete segmental blocks shall lay true and plumb. All horizontal and vertical joints shall be completely filled with mortar. Cover interior and exterior of structure with 15 mm (1/2 inch) of cement mortar applied with a trowel and finished to an even glazed surface.~~
 - ~~b. Precast reinforced concrete rings shall be installed true and plumb. The joints between rings and between rings and the base and top, shall be sealed with a preform flexible gasket material specifically manufactured for this type of application. Adjust the length of the rings so that the eccentric conical top section will be at the required elevation. Cutting the conical top section is not acceptable.~~
 - ~~c. Precast reinforced concrete manhole risers and tops. Install as specified for precast reinforced concrete rings.~~

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~~2. Rectangular Structures:~~

- ~~a. Reinforced concrete structures shall be installed in accordance with Division 03, CONCRETE.~~
- ~~b. Precast concrete structures shall be placed on a 200 mm (8 inch) reinforced concrete pad, or be provided with a precast concrete base section. Structures provided with a base section shall be set on 200 mm (8 inches) thick aggregate base course compacted to a minimum of 95 percent of the maximum density as determined by ASTM D698. Set precast section true and plumb. Seal all joints with preformed flexible gasket material.~~

~~3. Do not build structures when air temperature is 0 degrees C (32 degrees F), or below.~~

~~4. Invert channels shall be smooth and semicircular in shape conforming to inside of adjacent sewer section. Make changes in direction of flow with a smooth curve of as large a radius as size of structure will permit. Make changes in size and grade of channels gradually and evenly. Construct invert channels by one of the listed methods:~~

- ~~a. Forming directly in concrete base of structure.~~
- ~~b. Building up with brick and mortar.~~

~~5. Floor of structure outside the channels shall be smooth and slope toward channels not less than 1:12 (1 inch per foot) nor more than 1:6 (2 inches per foot). Bottom slab and benches shall be concrete.~~

~~6. The wall that supports access rungs or ladder shall be 90 degrees vertical from the floor of structure to manhole cover.~~

~~7. Install steps and ladders per the manufacturer's recommendations. Steps and ladders shall not move or flex when used. All loose steps and ladders shall be replaced by the Contractor.~~

~~8. Install manhole frames and covers on a mortar bed, and flush with the finish pavement. Frames and covers shall not move when subject to vehicular traffic. Install a concrete collar around the frame to protect the frame from moving until the adjacent pavement is placed. In unpaved areas, the rim elevation shall be 50 mm (2 inches) above the adjacent finish grade. Install a 200 mm (8 inches) thick, by 300~~

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~~mm (12 inches) concrete collar around the perimeter of the frame.~~

~~Slope the top of the collar away from the frame.~~

~~**3.9 SEWER AND MANHOLE SUPPORTS, CONCRETE CRADLES**~~

~~A. Reinforced concrete as detailed on the drawings. The concrete shall not restrict access for future maintenance of the joints within the piping system.~~

~~**3.10 DRY WELL AND VAULTS**~~

~~A. Install precast concrete vaults on a 200 mm (8 inches) compacted aggregate base course. The floor, walls, and top shall be level and plumb.~~

~~B. Vaults shall be sized as indicated on the drawings. Orientate vault and internal piping, valves, and appurtenances to provide access to all valves and appurtenances for operation and maintenance of the equipment.~~

~~C. Paint interior of dry well and vaults with 2 coats of alkyd enamel masonry paint.~~

~~**3.11 OIL AND GREASE INTERCEPTOR AND GREASE REMOVAL PIT**~~

~~A. Construct reinforced concrete as shown on the drawing, and in accordance with Division 03, CONCRETE. Install precast units as specified above.~~

~~B. Pipe and Fittings: Ductile iron, polylined, piping shall be used inside of trap, between trap and buildings, and between trap and manhole.~~

~~C. Manways and access manholes shall be set to finish grade providing adequate access to the unit. Slope pavement around the access-way to prevent stormwater from entering the unit.~~

~~D. Install baffles as indicated on the drawings.~~

~~**3.12 CLEANOUTS**~~

~~A. 150 mm (6 inches) in diameter and consisting of a ductile iron 45 degree fitting on end of run, or combination Y fitting and 1/8 bend in the run with ductile iron pipe extension, water tight plug, or cap and cast frame and cover flush with finished grade. Center-set cleanouts, located in unpaved areas, in a 300 mm by 300 mm by 150 mm (12 inches by 12 inches by 6 inches) thick concrete slab set flush with adjacent~~

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~~finished grade. Where cleanout is in force main, provide a blind flange top connection. The center of the flange shall be equipped with a 50 mm (2 inches) base valve to allow the pressure in the line to be relieved prior to removal of the blind flange. Frames and covers for pressure (force) mains shall be 600 mm (24 inches) in diameter.~~

- ~~B. The top of the cleanout assembly shall be 50 mm (2 inches) below the bottom of the cover to prevent loads being transferred from the frame and cover to the piping.~~

~~**3.13 SETTING OF GATE VALVES**~~

- ~~A. Avoid setting valves under pavement except where shown on the drawings.~~
- ~~B. Clean valve interior before installation.~~
- ~~C. Set valve plumb, restrain ends of valves when indicated on the drawing.~~
- ~~D. Set valve box cover flush with the finished grade. Valve box shall be centered over the operating nut.~~

~~**3.14 SETTING OF CHECK VALVES**~~

- ~~A. Check valves shall be installed in a vault. Direct burial of check valves are prohibited.~~
- ~~B. Check valves shall be set in the horizontal position, with adequate clearance to the structure to allow for movement of the lever and maintenance of the valve.~~
- ~~C. Clean the interior of the valve and check its operation prior to installation.~~
- ~~D. After installation, adjust the weight on the lever to provide proper operation in accordance with the manufacturer's recommendations.~~

~~**3.15 SETTING OF AIR RELEASE VALVES**~~

- ~~A. Set valves in vault with adequate space for maintenance of the valve. The vault shall have a solid floor to prevent all sanitary blowoff from being absorbed into the soils.~~
- ~~B. Valves shall be set plumb and supported to the vault. Maintain accessibility to the isolation valve on the air valve line.~~
- ~~C. Install the valve after the completion of testing of the pressure (force) main.~~

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~~3.16 INSPECTION OF SEWERS~~

- ~~A. Inspect and obtain the COR's approval. Thoroughly flush out before inspection. Lamp test between structures and show full bore indicating sewer is true to line and grade. Lip at joints, on the inside of gravity sewer lines are not acceptable.~~

~~3.17 STARTUP AND TESTING~~

- ~~A. Make tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.~~
- ~~B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.~~
- ~~C. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.~~

~~3.18 TESTING OF SANITARY SEWERS~~

- ~~A. Gravity Sewers and Manholes (Select one of the following):~~
- ~~1. Air Test: PVC Pipe, Uni-Bell Uni-B-6. Clean and isolate the section of sewer line to be tested. Plug or cap the ends of all branches, laterals, tees, wyes, and stubs to be included in the test to prevent air leakage. The line shall be pressurized to 28 kPa (4 psi) and allowed to stabilize. After pressure stabilization, the pressure shall be dropped to 24 kPa (3.5 psi) greater than the average back-pressure of any groundwater above the sewer. The minimum test time shall be as specified in Uni-Bell Uni-B-6.~~
 - ~~2. Exfiltration Test:~~
 - ~~a. Subject pipe to hydrostatic pressure produced by head of water at depth of 900 mm (3 feet) above invert of sewer at upper manhole under test. In areas where ground water exists, head of water shall be 900 mm (3 feet) above existing water table. Maintain head of water for one hour for full absorption by pipe body~~

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~~before testing. During one hour test period, measured maximum allowable rate of exfiltration for any section of sewer shall be 11 L (3.0 gallons) per hour per 30 m (100 feet).~~

~~b. If measurements indicate exfiltration is greater than maximum allowable leakage, take additional measurements until leaks are located. Repair and retest.~~

~~3. Infiltration Test: If ground water level is greater than 900 mm (3 feet) above invert of the upper manhole, infiltration tests are acceptable. Allowable leakage for this test will be the same as for the exfiltration test.~~

~~B. Pressure (Force) Mains: Test at 690 kPa (100 psi) for two hours. Leakage shall be per the following:~~

$$L = J \cdot D \cdot \sqrt{P} / 4500$$

~~Where:~~

~~L = Maximum Allowable Leakage in Gallons per Hour~~

~~J = Number of Joints in Test Area~~

~~D = Diameter of Pipe in Inches~~

~~P = Average Test Pressure (Psi)~~

~~C. Testing of Concrete Wet Well: No leakage with the wet well completely filled with water for a duration of 4 hours.~~

~~3.19 COMMISSIONING~~

~~A. Provide commissioning documentation in accordance with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.~~

~~B. Components provided under this section of the specification will be tested as part of a larger system.~~

~~3.20 DEMONSTRATION AND TRAINING~~

~~A. Provide services of manufacturer's technical representative for four hours to instruct each VA personnel responsible in the operation and maintenance of units.~~

~~B. Submit training plans and instructor qualifications in accordance with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.~~

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EHRM Infrastructure Upgrades-Tier 2

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SECTION 33 40 00
STORM SEWER UTILITIES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies materials and procedures for construction of outside, underground storm sewer systems that are complete and ready for operation. This includes piping, structures, and all other incidentals.

1.2 RELATED WORK

- A. Section 01 00 02, GENERAL REQUIREMENTS (Minor NCA Projects).
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA AND SAMPLES: Materials and Testing Report Submittals.
- C. Section 01 42 19, REFERENCE STANDARDS.
- D. Section 01 57 19, TEMPORARY ENVIRONMENTAL CONTROLS: Erosion and Sediment Control.
- E. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS.
- F. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
- G. Section 03 30 00, CAST-IN-PLACE CONCRETE: Concrete Work, Reinforcing, Placement and Finishing.
- H. Section 05 50 00, METAL FABRICATIONS: Fabrication of Steel Ladders.
- I. Section 22 14 00, FACILITY STORM DRAINAGE.
- J. Section 31 20 00, EARTH MOVING: Excavation, Trench Widths, Pipe Bedding, Backfill, Shoring, Sheeting, Bracing.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Association of State Highway and Transportation Officials (AASHTO):
- HB-17-2002.....Standard Specifications for Highway Bridges,
17th Edition
- M190-2004.....Standard Specification for Bituminous-Coated
Corrugated Metal Culvert Pipe and Pipe Arches

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- M252-2009.....Standard Specification for Corrugated
Polyethylene Drainage Pipe
- M294-2015.....Standard Specification for Corrugated
Polyethylene Pipe, 300 to 1500 mm (12 to 60
In.) Diameter
- C. American Concrete Institute (ACI):
- 318-2014.....Building Code Requirements for Structural
Concrete and Commentary
- 350-2006.....Code Requirements for Environmental Engineering
Concrete Structures and Commentary
- D. American Society of Mechanical Engineers (ASME):
- A112.6.3-2016.....Floor and Trench Drains
- A112.14.1-2003.....Backwater Valves
- A112.36.2M-1991.....Cleanouts
- E. American Society for Testing and Materials (ASTM):
- A48/A48M-2003 (R2012)...Standard Specification for Gray Iron Castings
- A242/A242M-2013.....Standard Specification for High-Strength Low-
Alloy Structural Steel
- A536-1984 (R2014).....Standard Specification for Ductile Iron
Castings
- A615/A615M-2016.....Standard Specification for Deformed and Plain
Carbon-Steel Bars for Concrete Reinforcement
- A760/A760M-2015.....Standard Specification for Corrugated Steel
Pipe, Metallic-Coated for Sewers and Drains
- A762/A762M-2015.....Standard Specification for Corrugated Steel
Pipe, Polymer Precoated for Sewers and Drains
- A798/A798M-2013.....Standard Specification for Installing Factory-
Made Corrugated Steel Pipe for Sewers and Other
Applications
- A849-2015.....Standard Specification for Post-Applied
Coatings, Pavings, and Linings for Corrugated
Steel Sewer and Drainage Pipe

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A929/A929M-2001(2013)...Standard Specification for Steel Sheet,
Metallic-Coated by the Hot-Dip Process for
Corrugated Steel Pipe

A1064/A1064M-2016.....Standard Specification for Carbon-Steel Wire
and Welded Wire Reinforcement, Plain and
Deformed, for Concrete

B745/B745M-2015.....Standard Specification for Corrugated Aluminum
Pipe for Sewers and Drains

B788/B788M-2009 (R2014).Standard Specification for Installing Factory-
Made Corrugated Aluminum Culverts and Storm
Sewer Pipe

C14-2015a.....Standard Specification for Nonreinforced
Concrete Sewer, Storm Drain, and Culvert Pipe

C33/C33M-2016.....Standard Specification for Concrete Aggregates

C76-2015a.....Standard Specification for Reinforced Concrete
Culvert, Storm Drain, and Sewer Pipe

C150/C150M-2016.....Standard Specification for Portland Cement

C443-2012.....Standard Specification for Joints for Concrete
Pipe and Manholes, Using Rubber Gaskets

C478-2015.....Standard Specification for Circular Precast
Reinforced Concrete Manhole Sections

C506-2016a.....Standard Specification for Reinforced Concrete
Arch Culvert, Storm Drain, and Sewer Pipe

C507-2015.....Standard Specification for Reinforced Concrete
Elliptical Culvert, Storm Drain, and Sewer Pipe

C828-2011.....Standard Test Method for Low-Pressure Air Test
of Vitrified Clay Pipe Lines

C890-2013.....Standard Practice for Minimum Structural Design
Loading for Monolithic or Sectional Precast
Concrete Water and Wastewater Structures

C891-2011.....Standard Practice for Installation of
Underground Precast Concrete Utility Structures

C913-2008.....Standard Specification for Precast Concrete
Water and Wastewater Structures

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C923-2008 (R2013)e1.....Standard Specification for Resilient Connectors
Between Reinforced Concrete Manhole Structures,
Pipes, and Laterals

C990-2009 (R2014).....Standard Specification for Joints for Concrete
Pipe, Manholes, and Precast Box Sections Using
Preformed Flexible Joint Sealants

C1103-2014.....Standard Specification for Joint Acceptance
Testing of Installed Precast Concrete Pipe
Sewer Lines

C1173-2010 (R2014).....Standard Specification for Flexible Transition
Couplings for Underground Piping Systems

C1433-2016a.....Standard Specification for Precast Reinforced
Concrete Monolithic Box Sections for Culverts,
Storm Drains, and Sewers

C1479-2013.....Standard Practice for Installation of Precast
Concrete Sewer, Storm Drain, and Culvert Pipe
Using Standard Installations

D448-2012.....Standard Classification for Sizes of Aggregate
for Road and Bridge Construction

D698-2012e2.....Standard Test Methods for Laboratory Compaction
Characteristics of Soil Using Standard Effort
(12,400 ft-lbf/ft³ (600 kN-m/m³))

D1056-2014.....Standard Specification for Flexible Cellular
Materials—Sponge or Expanded Rubber

D2321-2014e1.....Standard Practice for Underground Installation
of Thermoplastic Pipe for Sewers and Other
Gravity-Flow Applications

D2661-2014.....Standard Specification for Acrylonitrile-
Butadiene-Styrene (ABS) Schedule 40 Plastic
Drain, Waste, and Vent Pipe and Fittings

D3034-2015.....Standard Specification for Type PSM Poly(Vinyl
Chloride) (PVC) Sewer Pipe and Fittings

D3350-2014.....Standard Specification for Polyethylene
Plastics Pipe and Fittings Materials

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D3753-2012e1.....Standard Specification for Glass-Fiber-Reinforced Polyester Manholes and Wetwells

D4101-2014.....Standard Specification for Polypropylene Injection and Extrusion Materials

D5926-2015.....Standard Specification for Poly (Vinyl Chloride) (PVC) Gaskets for Drain, Waste, and Vent (DWV), Sewer, Sanitary, and Storm Plumbing Systems

F477-2014.....Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

F679-2015.....Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings

F714-2013.....Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter

F794-2003 (R2014).....Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter

F891-2010.....Standard Specification for Coextruded Poly(Vinyl Chloride) (PVC) Plastic Pipe With a Cellular Core

F894-2013.....Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe

F949-2015.....Standard Specification for Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe With a Smooth Interior and Fittings

F1417-2011a (R2015).....Standard Practice for Installation Acceptance of Plastic Non-Pressure Sewer Lines Using Low-Pressure Air

F1668-2008.....Standard Guide for Construction Procedures for Buried Plastic Pipe

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

F. American Water Works Association (AWWA):

C105-2010.....Polyethylene Encasement for Ductile-Iron Pipe
Systems

C110-2012.....Ductile-Iron and Gray-Iron Fittings

C219-2011.....Bolted, Sleeve-Type Couplings for Plain-End
Pipe

C600-2010.....Installation of Ductile iron Mains and Their
Appurtenances

C900-2007.....Polyvinyl Chloride (PVC) Pressure Pipe and
Fabricated Fittings, 4 In. Through 12 In. (100
mm Through 300 mm), for Water Transmission and
Distribution

M23-2002.....PVC Pipe: Design And Installation, Second
Edition

G. National Stone, Sand and Gravel Association (NSSGA):

.....Quarried Stone for Erosion and Sediment Control

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 33 40 00, STORM SEWER UTILITIES", with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

D. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:

1. Include complete list indicating all components of the systems.

2. Include complete diagrams of the internal wiring for each item of equipment.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.
- E. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
- F. Submit training plans and instructor qualifications in accordance with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

1.5 QUALITY ASSURANCE

- A. Products Criteria:
 1. When two or more units of the same type or class of materials or equipment are required, these units shall be products of one manufacturer.
 2. A nameplate bearing manufacturer's name or trademark, including model number, shall be securely affixed in a conspicuous place on equipment. In addition, the model number shall be either cast integrally with equipment, stamped, or otherwise permanently marked on each item of equipment.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic manholes, pipe, and fittings in direct sunlight.
- B. Handle manholes, catch basins, and stormwater inlets according to manufacturer's written rigging instructions.

1.7 COORDINATION

- A. Coordinate connection to storm sewer main with the Public Agency providing storm sewer off-site drainage.
- B. Coordinate exterior utility lines and connections to building services up to the actual extent of building wall.

1.8 WARRANTY

- A. Guaranty: Warranty of Construction, FAR clause 52.246-21.
- B. The Contractor shall remedy any defect due to faulty material or workmanship and pay for any damage to other work resulting therefrom within a period of one year from final acceptance. Further, the Contractor will furnish all manufacturers' and suppliers' written

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

guarantees and warranties covering materials and equipment furnished under this Contract.

1.9 AS-BUILT DOCUMENTATION

- A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.
- C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them in Auto-CAD version 2024 provided on CD or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement.
- D. Certification documentation shall be provided to COR 10 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and certification that all results of tests were within limits specified.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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PART 2 - PRODUCTS

2.1 FACTORY-ASSEMBLED PRODUCTS

- A. Standardization of components shall be maximized to reduce spare part requirements. Guarantee performance of assemblies of components, and shall repair or replace elements of the assemblies as required to deliver specified performance of the complete assembly.

2.2 STEEL PIPE AND FITTINGS

- A. Steel pipe and fittings shall be as per ASTM A760/A760M or ASTM A762/A762M.
- B. Type of pipe: IR, or IIR.
- C. Corrugations: Helical 20 by 20 by 191 mm (3/4 by 3/4 by 7-1/2 inch) corrugations.
- D. Internal Coating: Internal coating shall be concrete lined as per ASTM A849.
- E. Exterior Coating: Zinc Coated.
- F. Gaskets: ASTM D1056, Type 2.
- G. Connecting Bands: To be same type and size as the ends of the pipe being connected.

2.3 ALUMINUM PIPE AND FITTINGS

- A. Corrugated aluminum pipe and fittings shall be ASTM B745/B745M, Type I with fittings of similar form and construction as pipe.
 - 1. Special joint bands shall be corrugated steel with O-ring seals.
 - 2. Standard joint bands shall be corrugated steel.

2.4 ABS PIPE AND FITTINGS

- A. ABS Sewer Pipe and Fittings: Pipe and fittings, DN 80 to DN 150 (NPS 3 to NPS 6) shall conform to ASTM D2661, with ends suitable for solvent cement joints.

2.5 PE PIPE AND FITTINGS

- A. Smoothwall PE drainage pipe and fittings, DN 80 to DN 250 (NPS 3 to NPS 10); ASTM F714, DR 21 with smooth waterway for coupling joints.
- B. Corrugated PE pipe and fittings, DN 300 to DN 1500 (NPS 12 to NPS 60); AASHTO M294, Type S with smooth waterway for coupling joints. Pipe shall be produced from PE certified by the resin producer as meeting the requirements of ASTM D3350, minimum cell class 335434C.

Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft-AE Project No. 22-113

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Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

1. Water tight joints shall be made using a PVC or PE coupling and rubber gaskets as recommended by the pipe manufacturer. Rubber gaskets shall conform to ASTM F477. Soil tight joints shall conform to requirements in AASHTO HB-17, Division II, for soil tightness and shall be as recommended by the manufacturer.

C. Profile Wall PE Pipe: Pipe shall comply with ASTM F894, RSC 160 with bell and spigot ends.

1. Profile Wall PE Plastic Pipe Joints: Joints shall be as per ASTM F894, gasketed type with integral bell.

2.6 PVC PIPE AND FITTINGS

A. PVC Cellular-Core Pipe And Fittings:

1. Pipe: ASTM F891, Sewer and Drain Series, PS 50 minimum stiffness, PVC cellular-core pipe with plain ends for solvent-cemented joints.
2. Fittings: ASTM D3034, SDR 35, PVC socket-type fittings.

B. PVC Corrugated Sewer Piping:

1. Pipe: ASTM F949, PS46, corrugated pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: ASTM F949, PVC molded or fabricated, socket type.
3. Gaskets: ASTM F477, elastomeric seals.

C. PVC Profile Sewer Piping:

1. Pipe: ASTM F794, Series 46, gravity sewer pipe with bell-and-spigot ends.
2. Fittings: ASTM D3034, PVC with bell ends.
3. Gaskets: ASTM F477, elastomeric seals.

D. PVC Type PSM Sewer Piping:

1. Pipe: ASTM D3034, SDR 35, PVC Type PSM sewer pipe with bell-and-spigot ends.
2. Fittings: ASTM D3034, PVC with bell ends.
3. Gaskets: ASTM F477, elastomeric seals.

E. PVC Gravity Sewer Piping:

1. Pipe and fittings shall be ASTM F679, PS46, PVC gravity sewer pipe with bell-and-spigot ends.
2. Gaskets: ASTM F477, elastomeric seals for gasketed joints.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

F. PVC Pressure Piping:

1. Pipe: AWWA C900, Class 100 PVC pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: AWWA C900, Class 100 PVC pipe with bell ends
3. Gaskets: ASTM F477, elastomeric seals.

2.7 CONCRETE PIPE AND FITTINGS

- A. Non-reinforced concrete sewer pipe and fittings shall be ASTM C14, Class 2, with bell-and-spigot ends and gasketed joints with ASTM C443, rubber gaskets.
- B. Reinforced concrete sewer pipe and fittings shall be ASTM C76.
 1. Bell-and-spigot ends and gasketed joints with ASTM C443, rubber gaskets.
 2. Class II: Wall A
- C. Reinforced arch culvert and storm drain pipe and fittings shall be ASTM C506, Class A-III and gasketed joints with ASTM C443, rubber gaskets.
- D. Reinforced concrete elliptical culvert and storm drain pipe and fittings shall be ASTM C507, Class HE III and gasketed joints with ASTM C443, rubber gaskets.

2.8 NONPRESSURE TRANSITION COUPLINGS

- A. Comply with ASTM C1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground non-pressure piping. Include ends of same sizes as piping to be joined, and corrosion resistant metal tension band and tightening mechanism on each end.
- B. Sleeve Materials:
 1. For concrete pipes: ASTM C443, rubber.
 2. For plastic pipes: ASTM F477, elastomeric seal or ASTM D5926, PVC.
 3. For dissimilar pipes: ASTM D5926, PVC or other material compatible with pipe materials being joined.
- C. Unshielded, Flexible Couplings: Couplings shall be an elastomeric sleeve with stainless steel shear ring and corrosion resistant metal tension band and tightening mechanism on each end.
- D. Shielded, flexible couplings shall be elastomeric or rubber sleeve with full length, corrosion resistant outer shield and corrosion resistant metal tension band and tightening mechanism on each end.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- E. Ring-type, flexible couplings shall be elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.

2.9 PRESSURE PIPE COUPLINGS

- A. Couplings: AWWA C219, tubular sleeve coupling, with center sleeve, gaskets, end rings, and bolt fasteners.
- B. Metal, bolted, sleeve-type, reducing or transition coupling, for joining underground pressure piping. Include 1034 kPa (150 psi) minimum pressure rating and ends sized to match adjoining pipes.
- C. Center Sleeve Material: Stainless steel
- D. Gasket Material: Natural or synthetic rubber.
- E. Metal Component Finish: Corrosion resistant coating or material.

2.10 EXPANSION JOINTS AND DEFLECTION FITTINGS

- A. Ductile iron flexible expansion joints: Compound fitting with combination of flanged and mechanical joint ends complying with AWWA C110. Include two gasketed ball joint sections and one or more gasketed sleeve sections, rated for 1724 kPa (250 psi) minimum working pressure and for offset and expansion indicated.
- B. Ductile iron expansion joints: Three piece assemblies of telescoping sleeve with gaskets and restrained-type, steel with protective coating, bell-and-spigot end sections complying with AWWA C110. Include rating for 1724 kPa (250 psi) minimum working pressure and for expansion indicated.
- C. Ductile iron deflection fittings: Compound coupling fitting, with ball joint, flexing section, gaskets, and restrained joint ends, complying with AWWA C110. Include rating for 1724 kPa (250 psi) minimum working pressure and for up to 15 degrees of deflection.

2.11 BACKWATER VALVES

- A. Cast Iron Backwater Valves: ASME A112.14.1, gray iron body and bolted cover, with bronze seat.
 - 1. Horizontal type; with swing check valve and hub-and-spigot ends.
- B. Plastic backwater valves: Horizontal type; with PVC body, PVC removable cover, and PVC swing check valve.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

2.12 CLEANOUTS

- A. Cast Iron Cleanouts: ASME A112.36.2M, round, gray iron housing with clamping device and round, secured, scoriated, gray iron cover. Include gray iron ferrule with inside calk or spigot connection and countersunk, tapered thread, brass closure plug.
 - 1. Top-Loading Classification(s): Medium Duty.
 - 2. Pipe fitting and riser to cleanout shall be same material as main pipe line.
- B. Plastic Cleanouts shall have PVC body with PVC threaded plug. Pipe fitting and riser to cleanout shall be of same material as main line pipe.

2.13 DRAINS

- A. Cast Iron Area Drains: ASME A112.6.3, gray iron round body with anchor flange and round secured grate. Include bottom outlet with inside calk or spigot connection, of sizes indicated.
 - 1. Top-Loading Classification(s): Medium Duty.
- B. Cast Iron Trench Drains: ASME A112.6.3, 150 mm (6 inch) wide top surface, rectangular body with anchor flange or other anchoring device, and rectangular secured grate. Include units of total length indicated and quantity of bottom outlets with inside calk or spigot connections, of sizes indicated.
 - 1. Top-Loading Classification(s): Medium Duty.
- C. Steel Trench Drains: ASTM A242/A242M, welded steel plate, to form rectangular body with uniform bottom downward slope of 2 percent toward outlet, anchor flange, and grate.
 - 1. Plate Thicknesses: 3.2 mm (1/8 inch).
 - 2. Overall Widths: 191 mm (7-1/2 inches).
- D. Grate openings shall be 6 mm (1/4 inch) circular.

2.14 ENCASEMENT FOR PIPING

- A. Material: AWWA C105 linear low-density polyethylene film of 0.20 mm (0.008 inch) minimum thickness.
- B. Form: Tube.
- C. Color: Natural.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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2.15 MANHOLES AND CATCH BASINS

A. Standard Precast Concrete Manholes:

1. Description: ASTM C478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
2. Diameter: 1200 mm (48 inches) minimum unless otherwise indicated.
3. Ballast: Increase thickness of precast concrete sections or add concrete to base section as required to prevent flotation.
4. Base Section: 150 mm (6 inch) minimum thickness for floor slab and 100 mm (4 inch) minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.
5. Riser Sections: 100 mm (4 inch) minimum thickness, and lengths to provide depth indicated.
6. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated, and top of cone of size that matches grade rings.
7. Joint Sealant: ASTM C990, bitumen or butyl rubber.
8. Resilient Pipe Connectors: ASTM C923, cast or fitted into manhole walls, for each pipe connection.
9. Steps: If total depth from floor of manhole to finished grade is greater than 1500 mm (60 inches). ASTM A615/A615M, deformed, 15 mm (1/2 inch) steel reinforcing rods encased in ASTM D4101, PP, width of 400 mm (16 inches) minimum, spaced at 300 to 400 mm (12 to 16 inch) intervals.
10. Adjusting Rings: Reinforced concrete rings, 150 to 225 mm (6 to 9 inch) total thickness, to match diameter of manhole frame and cover, and height as required to adjust manhole frame and cover to indicated elevation and slope.

B. Designed Precast Concrete Structures:

1. Description: ASTM C913; designed for A-16 (AASHTO HS20-44), heavy-traffic, structural loading; of depth, shape, and dimensions indicated, with provision for sealant joints.
2. Ballast: Increase thickness of one or more precast concrete sections or add concrete to manhole as required to prevent flotation.
3. Joint Sealant: ASTM C990, bitumen or butyl rubber.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

4. Resilient Pipe Connectors: ASTM C923, cast or fitted into manhole walls, for each pipe connection.
5. Steps: If total depth from floor of structure to finished grade is greater than 1500 mm (60 inches). ASTM A615/A615M deformed, 15 mm (1/2 inch) steel reinforcing rods encased in ASTM D 4101, PP, width of 400 mm (16 inches) minimum, spaced at 300 to 400 mm (12 to 16 inch) intervals.
6. Adjusting Rings: Reinforced concrete rings, 150 to 225 mm (6 to 9 inches) total thickness, to match diameter of manhole frame and cover, and height as required to adjust manhole frame and cover to indicated elevation and slope.

C. Fiberglass Manholes:

1. Description: ASTM D3753.
2. Diameter: 1200 mm (48 inches) minimum unless otherwise indicated.
3. Ballast: Increase thickness of concrete base as required to prevent flotation.
4. Base Section: Concrete, 200 mm (8 inch) minimum thickness.
5. Resilient Pipe Connectors: ASTM C923, cast or fitted into manhole walls, for each pipe connection.
6. Steps: If total depth from floor of manhole to finished grade is greater than 1500 mm (60 inches). ASTM A615/A615M, deformed, 15 mm (1/2 inch) steel reinforcing rods encased in ASTM D4101, PP, width of 400 mm (16 inches) minimum, spaced at 300 to 400 mm (12 to 16 inch) intervals.
7. Adjusting Rings: Reinforced concrete rings, 150 to 225 mm (6 to 9 inch) total thickness, to match diameter of manhole frame and cover, and height as required to adjust manhole frame and cover to indicated elevation and slope.

D. Manhole Frames and Covers:

1. Description: Ferrous; 600 mm (24 inch) ID by 175 to 225 mm (7 to 9 inch) riser with 100 mm (4 inch) minimum width flange and 660 mm (26 inch) diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

2. Material: ASTM A48/A48M, Class 35 gray iron unless otherwise indicated.

2.16 CONCRETE FOR MANHOLES AND CATCH BASINS

- A. General: Cast-in-place concrete according to ACI 318, ACI 350, and the following:
 1. Cement: ASTM C150/C150M, Type II.
 2. Fine Aggregate: ASTM C33/C33M, sand.
 3. Coarse Aggregate: ASTM C33/C33M, crushed gravel.
 4. Water: Potable.
- B. Concrete Design Mix: 27.6 MPa (4000 psi) minimum, compressive strength in 28 days.
 1. Reinforcing Fabric: ASTM A1064/A1064M, steel, welded wire fabric, plain.
 2. Reinforcing Bars: ASTM A615/A615M, Grade 60 420 MPa (60,000 psi) deformed steel.
- C. Manhole Channels and Benches: Channels shall be the main line pipe material. Include benches in all manholes and catch basins.
 1. Channels: Main line pipe material or concrete invert. Height of vertical sides to 3/4 of pipe diameter. Form curved channels with smooth, uniform radius and slope. Invert Slope: Same slope as the main line pipe. Bench to be concrete, sloped to drain into channel. Minimum of 6 inch slope from main line pipe to wall sides.

2.17 POLYMER-CONCRETE, CHANNEL DRAINAGE SYSTEMS

- A. General Requirements for Polymer-Concrete, Channel Drainage Systems: Modular system of precast, polymer-concrete channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling. Include quantity of units required to form total lengths indicated.
- B. Sloped-Invert, Polymer-Concrete Systems:
 1. Channel Sections:
 - a. Interlocking joint, precast, modular units with end caps.
 - b. 100 mm (4 inch) inside width and deep, rounded bottom, with built-in invert slope of 0.6 percent and with outlets in quantities, sizes, and locations indicated.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- c. Extension sections necessary for required depth.
- d. Frame: Include gray iron or steel frame for grate.
- 2. Grates:
 - a. Manufacturer's designation "Medium Duty," with slots or perforations that fit recesses in channels.
 - b. Material: Galvanized steel.
- 3. Covers: Solid gray iron if indicated.
- 4. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.
- C. Narrow-Width, Level-Invert, Polymer-Concrete Systems:
 - 1. Channel Sections:
 - a. Interlocking joint, precast, modular units with end caps.
 - b. 125 mm (5 inch) inside width and 248 mm (9-3/4 inch) deep, rounded bottom, with level invert and with DN 100 (NPS 4) outlets in quantities, sizes, and locations indicated.
 - 2. Grates:
 - a. Slots or perforations that fit recesses in channels.
 - b. Material: Galvanized steel.
 - 3. Covers: Solid gray iron if indicated.
 - 4. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.
- D. Wide-Width, Level-Invert, Polymer-Concrete Systems:
 - 1. Channel Sections:
 - a. Interlocking joint, precast, modular units with end caps.
 - b. 200 mm (8 inch) inside width and 350 mm (13-3/4 inch) deep, rounded bottom, with level invert and with outlets in quantities, sizes, and locations indicated.
 - 2. Grates:
 - a. Slots or other openings that fit recesses in channels.
 - b. Material: Gray iron.
 - 3. Covers: Solid gray iron if indicated.
 - 4. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- E. Drainage Specialties: Precast, polymer-concrete units.
1. Large Catch Basins:
 - a. 600 by 300 mm (24 by 12 inch) polymer-concrete body, with outlets in quantities and sizes indicated.
 - b. Gray iron slotted grate.
 - c. Frame: Include gray iron or steel frame for grate.
 2. Small Catch Basins:
 - a. 483 to 600 mm by approximately 150 mm (19 to 24 inch by approximately 6 inch) polymer-concrete body, with outlets in quantities and sizes indicated.
 - b. Gray iron slotted grate.
 - c. Frame: Include gray iron or steel frame for grate.
 3. Oil Interceptors:
 - a. Polymer-concrete body with interior baffle and four steel support channels and two 6 mm (1/4 inch) thick, steel plate covers.
 - b. Steel plate covers.
 - c. Capacity: 530 L (140 gal.).
 - d. Inlet and Outlet: DN 100 (NPS 4).
 4. Sediment Interceptors:
 - a. 686 mm (27 inch) square, polymer-concrete body, with outlets in quantities and sizes indicated.
 - b. 600 mm (24 inch) square, gray iron frame and slotted grate.
- F. Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.
- G. Channel Section Joining and Fastening Materials: As recommended by system manufacturer.

2.18 PLASTIC, CHANNEL DRAINAGE SYSTEMS

- A. General Requirements for Plastic, Channel Drainage Systems:
1. Modular system of plastic channel sections, grates, and appurtenances.
 2. Designed so grates fit into frames without rocking or rattling.
 3. Number of units required to form total lengths indicated.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

B. Fiberglass Systems:

1. Channel Sections:

- a. Interlocking joint, fiberglass modular units, with built-in invert slope of approximately 1 percent and with end caps.
- b. Rounded or inclined inside bottom surface, with outlets in quantities, sizes, and locations indicated.
- c. Width: 150 mm (6 inches).

2. Factory- or field-attached frames that fit channel sections and grates.

- a. Material: Galvanized steel.

3. Grates with slots or perforations that fit frames.

- a. Material: Galvanized steel.

4. Covers: Solid gray iron if indicated.

5. Drainage Specialties:

- a. Large Catch Basins: 600 mm (24 inch) square plastic body, with outlets in quantities and sizes indicated. Include gray iron frame and slotted grate.
- b. Small Catch Basins: 300 by 600 mm (12 by 24 inch) plastic body, with outlets in quantities and sizes indicated. Include gray iron frame and slotted grate.

C. PE Systems:

1. Channel Sections: Interlocking joint, PE modular units, 100 mm (4 inches) wide, with end caps. Include rounded bottom, with level invert and with outlets in quantities, sizes, and locations indicated.

2. Grates: PE, ladder shaped; with stainless steel screws.

3. Color: Gray unless otherwise indicated.

4. Drainage Specialties: Include the following PE components:

- a. Drains: 100 mm (4 inch) diameter, round, slotted top; with DN 100 (NPS 4) bottom outlet.
- b. Drains: 200 mm (8 inch) diameter, round, slotted top; with DN 150 (NPS 6) bottom outlet.
- c. Drains: 100 mm (4 inch) square, slotted top; with DN 80 (NPS 3) bottom outlet.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- d. Drains: 200 mm (8 inch) square, slotted top; with DN 150 (NPS 6) bottom outlet.
- e. Catch Basins: 300 mm (12 inch) square plastic body, with outlets in quantities and sizes indicated. Include PE slotted grate 298 mm (11-3/4 inches) square by 28.6 mm (1-1/8 inches) thick.
- D. Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.
- E. Channel Section Joining and Fastening Materials: As recommended by system manufacturer.

2.19 PIPE OUTLETS

- A. Head walls: Cast-in-place reinforced concrete, with apron and tapered sides.
- B. Riprap basins: Broken, irregularly sized and shaped, graded stone according to NSSGA's "Quarried Stone for Erosion and Sediment Control."
 - 1. Average Size: NSSGA No. R-4, screen opening 75 mm (3 inches).
- C. Filter Stone: NSSGA's "Quarried Stone for Erosion and Sediment Control," No. FS-2, 6 mm (No. 4) screen opening, average size graded stone.
- D. Energy Dissipaters: To be as per NSSGA's "Quarried Stone for Erosion and Sediment Control," No. A-1, 2721 kg (3 ton) average weight armor stone, unless otherwise indicated.

2.20 DRY WELLS

- A. Concrete Well: ASTM C913, precast, reinforced, perforated concrete rings. Include the following:
 - 1. Concrete Floor: 27.6 MPa (4000 psi) minimum 28 day compressive strength.
 - 2. Cover: Liftoff-type concrete cover with cast in lift rings
 - 3. Wall Thickness: 100 mm (4 inches) minimum with 25 mm (1 inch) diameter or 25 by 75 mm (1 by 3 inch) maximum slotted perforations arranged in rows parallel to axis of ring
 - 4. Total free area of perforations: Approximately 15 percent of ring interior surface
 - 5. Ring construction: Designed to be self-aligning.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

6. Filtering material: ASTM D448, Size No. 24, 20 to 65 mm (3/4 to 2-1/2 inch) washed, crushed stone or gravel.

2.21 STORMWATER DISPOSAL SYSTEMS

- A. Pipe Systems: Perforated manifold, header, and lateral piping complying with AASHTO M252 for DN 250 (NPS 10) and smaller, AASHTO M294 for DN 300 to DN 1500 (12 NPS to NPS 60). Include fittings, couplings, seals, and filter fabric.

2.22 HEADWALLS

- A. Headwalls: Cast-in-place concrete with a minimum compressive strength of 20 MPa (3000 psi) at 28 days.

2.23 FLARED END SECTIONS

- A. Flared End Sections: Sections shall be of standard design of reinforced concrete in accordance with DOT standards.

2.24 PRECAST REINFORCED CONCRETE BOX CULVERT

- A. Precast Reinforced Concrete Box Culvert: Designed for highway loadings with 600 mm (2 feet) of cover or more subjected to dead load only, conforming to ASTM C1433. For less than 600 mm (2 feet) of cover, subjected to highway loading, conform to ASTM C1433.

2.25 RESILIENT CONNECTORS AND DOWNSPOUT BOOTS FOR BUILDING ROOF DRAINS

- A. Resilient connectors and downspout boots: Flexible, watertight connectors used for connecting pipe to manholes and inlets, and shall conform to ASTM C923.

2.26 WARNING TAPE

- A. Standard, 4-Mil polyethylene 75 mm (3 inch) wide tape detectable type, purple with black letters, and imprinted with "CAUTION BURIED STORM SEWER BELOW".

PART 3 - EXECUTION

3.1 GENERAL

- A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

3.2 PIPE BEDDING

- A. The bedding surface of the pipe shall provide a firm foundation of uniform density throughout the entire length of pipe. Concrete pipe

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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requirements are such that when no bedding class is specified, concrete pipe shall be bedded in a soil foundation accurately shaped and rounded to conform to the lowest 1/4 of the outside portion of circular pipe. When necessary, the bedding shall be tamped. Bell holes and depressions for joints shall not be more than the length, depth, and width required for properly making the particular type of joint. Plastic pipe bedding requirements shall meet the requirements of ASTM D2321. Bedding, haunching and initial backfill shall be either Class IB or Class II material. Corrugated metal pipe bedding requirements shall conform to ASTM A798/A798M.

3.3 PIPING INSTALLATION

- A. Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
- B. Install piping with 900 mm (36 inch minimum cover as shown on the Drawings.
- C. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
 - 1. Do not lay pipe on unstable material, in wet trench or when trench and weather conditions are unsuitable for the work.
 - 2. Support pipe on compacted bedding material. Excavate bell holes only large enough to properly make the joint.
 - 3. Inspect pipes and fittings, for defects before installation. Defective materials shall be plainly marked and removed from the site. Cut pipe shall have smooth regular ends at right angles to axis of pipe.
 - 4. Clean interior of all pipe thoroughly before installation. When work is not in progress, open ends of pipe shall be closed securely to prevent entrance of storm water, dirt or other substances.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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5. Lower pipe into trench carefully and bring to proper line, grade, and joint. After jointing, interior of each pipe shall be thoroughly wiped or swabbed to remove any dirt, trash or excess jointing materials.
 6. Do not walk on pipe in trenches until covered by a depth of 300 mm (12 inches) over the crown of the pipe.
 7. Warning tape shall be continuously placed 300 mm (12 inches) above storm sewer piping.
- D. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
- E. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
- F. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.
- G. Install gravity-flow, nonpressure drainage piping according to the following:
1. Install piping pitched down in direction of flow.
 2. Install corrugated steel piping according to ASTM A798/A798M.
 3. Install corrugated aluminum piping according to ASTM B788/B788M.
 4. Install ABS sewer piping according to ASTM D2321 and ASTM F1668.
 5. Install PE corrugated sewer piping according to ASTM D2321 with gasketed joints.
 6. Install PVC cellular-core piping, PVC sewer piping, and PVC profile gravity sewer piping, according to ASTM D2321 and ASTM F1668.
 7. Install reinforced concrete sewer piping according to ASTM C1479.

3.4 REGRADING

- A. Raise or lower existing manholes and structures frames and covers in regraded areas to finish grade. Carefully remove, clean and salvage cast iron frames and covers. Adjust the elevation of the top of the manhole or structure as detailed on the drawings. Reset cast iron frame and cover, grouting below and around the frame. Install concrete collar around reset frame and cover as specified for new construction.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- B. During periods when work is progressing on adjusting manholes or structures cover elevations, install a temporary cover above the bench of the structure or manhole. The temporary cover shall be installed above the high flow elevation within the structure, and shall prevent debris from entering the wastewater stream.

3.5 CONNECTIONS TO EXISTING VA-OWNED MANHOLES

- A. Make pipe connections and alterations to existing manholes so that finished work will conform as nearly as practicable to the applicable requirements specified for new manholes, including concrete and masonry work, cutting, and shaping.

3.6 DRAIN INSTALLATION

- A. Install type of drains in locations indicated.
1. Use Light-Duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.
 2. Use Medium-Duty, top-loading classification cleanouts in paved foot-traffic areas.
 3. Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.
 4. Use Extra-Heavy-Duty, top-loading classification cleanouts in roads.
- B. Embed drains in 100 mm (4 inch) minimum concrete around bottom and sides.
- C. Set drain frames and covers with tops flush with pavement surface.
- D. Assemble trench sections with flanged joints and embed trench sections in 100 mm (4 inch) minimum concrete around bottom and sides.

3.7 MANHOLE INSTALLATION

- A. Install manholes, complete with appurtenances and accessories indicated. Install precast concrete manhole sections with sealants according to ASTM C891.
- B. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 75 mm (3 inches) above finished surface elsewhere unless otherwise indicated.
- C. Circular Structures:
1. Precast concrete segmental blocks shall lay true and plumb. All horizontal and vertical joints shall be completely filled with

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- mortar. Parge interior and exterior of structure with 15 mm (1/2 inch) or cement mortar applied with a trowel and finished to an even glazed surface.
2. Precast reinforced concrete rings shall be installed true and plumb. The joints between rings and between rings and the base and top shall be sealed with a preform flexible gasket material specifically manufactured for this type of application. Adjust the length of the rings so that the eccentric conical top section will be at the required elevation. Cutting the conical top section is not acceptable.
 3. Precast reinforced concrete manhole risers and tops. Install as specified for precast reinforced concrete rings.
- D. Rectangular Structures:
1. Precast concrete structures shall be placed on a 200 mm (8 inch) reinforced concrete pad, or be provided with a precast concrete base section. Structures provided with a base section shall be set on a 200 mm (8 inch) thick aggregate base course compacted to a minimum of 95 percent of the maximum density as determined by ASTM D698. Set precast section true and plumb. Seal all joints with preform flexible gasket material.
 2. Do not build structures when air temperature is 0 degrees C (32 degrees F), or below.
 3. Invert channels shall be smooth and semicircular in shape conforming to inside of adjacent sewer section. Make changes in direction of flow with a smooth curve of as large a radius as size of structure will permit. Make changes in size and grade of channels gradually and evenly. Construct invert channels by one of the listed methods:
 - a. Forming directly in concrete base of structure.
 - b. Building up with brick and mortar.
 4. Floor of structure outside the channels shall be smooth and slope toward channels not less than 1 to 12 or more than 1 to 6. Bottom slab and benches shall be concrete.
 5. The wall that supports access rungs or ladder shall be 90 deg vertical from the floor of structure to manhole cover.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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6. Install steps and ladders per the manufacturer's recommendations. Steps and ladders shall not move or flex when used. All loose steps and ladders shall be replaced by the Contractor.
7. Install manhole frames and covers on a mortar bed, and flush with the finish pavement. Frames and covers shall not move when subject to vehicular traffic. Install a concrete collar around the frame to protect the frame from moving until the adjacent pavement is placed. In unpaved areas, the rim elevation shall be 50 mm (2 inches) above the adjacent finish grade. Install a 200 mm (8 inch) thick, by 300 mm (12 inch) concrete collar around the perimeter of the frame. Slope the top of the collar away from the frame.

3.8 CATCH BASIN INSTALLATION

- A. Construct catch basins to sizes and shapes indicated.
- B. Set frames and grates to elevations indicated.

3.9 STORMWATER INLET AND OUTLET INSTALLATION

- A. Construct inlet head walls, aprons, and sides of reinforced concrete.
- B. Construct riprap of broken stone.
- C. Install outlets that spill onto grade, anchored with concrete.
- D. Install outlets that spill onto grade, with flared end sections that match pipe.
- E. Construct energy dissipaters at outlets.

3.10 DRY WELL INSTALLATION

- A. Excavate hole to diameter of at least 150 mm (6 inches) greater than outside of dry well. Do not extend excavation into groundwater table.
- B. Install precast, concrete ring dry wells according to the following:
 1. Assemble rings to depth indicated, and extend rings to height where top of cover will be approximately 200 mm (8 inches) below finished grade.
 2. Backfill bottom-inside of rings with filtering material to level at least 300 mm (12 inches) above bottom.
 3. Extend effluent inlet pipe 300 mm (12 inches) into rings and terminate into side of tee fitting.
 4. Backfill around outside of rings with filtering material to top level of rings and install cover over top of rings.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- C. Install manufactured, PE dry wells according to manufacturer's written instructions and the following:
 - 1. Assemble and install panels and cover.
 - 2. Backfill bottom-inside of rings with filtering material to level at least 300 mm (12 inches) above bottom.
 - 3. Extend effluent inlet pipe 300 mm (12 inches) into unit and terminate into side of tee fitting.
 - 4. Install filter fabric around outside of unit.
 - 5. Install filtering material around outside of unit.
- D. Install constructed-in-place dry wells according to the following:
 - 1. Install brick lining material dry and laid flat, with staggered joints for seepage. Build to diameter and depth indicated.
 - 2. Install block lining material dry, with staggered joints and 20 percent minimum of blocks on side for seepage. Install precast concrete rings with notches or weep holes for seepage. Build to diameter and depth indicated.
 - 3. Extend lining material to height where top of manhole will be approximately 200 mm (8 inches) below finished grade.
 - 4. Backfill bottom of inside of lining with filtering material to level at least 300 mm (12 inches) above bottom.
 - 5. Extend effluent inlet pipe 300 mm (12 inches) into lining and terminate into side of tee fitting.
 - 6. Backfill around outside of lining with filtering material to top level of lining.
 - 7. Install manhole over top of dry well. Support cover on undisturbed soil. Do not support cover on lining.

3.11 CHANNEL DRAINAGE SYSTEM INSTALLATION

- A. Install with top surfaces of components, except piping, flush with finished surface.
- B. Assemble channel sections to form slope down toward drain outlets. Use sealants, adhesives, fasteners, and other materials recommended by system manufacturer.
- C. Embed channel sections and drainage specialties in 100 mm (4 inch) minimum concrete around bottom and sides.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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- D. Assemble channel sections with flanged or interlocking joints.
- E. Embed channel sections in 100 mm (4 inch) minimum concrete around bottom and sides.

3.12 STORMWATER DISPOSAL SYSTEM INSTALLATION

- A. Piping Systems: Excavate trenches of width and depth, and install piping system, filter fabric, and backfill, according to piping manufacturer's written instructions.

3.13 CONNECTIONS

- A. Connect nonpressure, gravity-flow drainage piping in building's storm building drains specified in Section 22 14 00, FACILITY STORM DRAINAGE.
- B. Encase entire connection fitting, plus 150 mm (6 inch) overlap, with not less than 150 mm (6 inches) of concrete with 28-day compressive strength of 20 MPa (3000 psi).
- C. Make connections to existing piping and underground manholes.
 - 1. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe; install wye fitting into existing piping.
 - 2. Make branch connections from side into existing piping, DN 100 to DN 500 (NPS 4 to NPS 20). Remove section of existing pipe, install wye fitting into existing piping.
 - 3. Make branch connections from side into existing piping, DN 525 (NPS 21) or larger, or to underground manholes and structures by cutting into existing unit and creating an opening large enough to allow 75 mm (3 inches) of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall unless otherwise indicated. On outside of pipe, manhole, or structure wall, use epoxy-bonding compound as interface between new and existing concrete and piping materials.
 - 4. Protect existing piping, manholes, and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- D. Pipe couplings, expansion joints, and deflection fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
 - 1. Use nonpressure-type flexible couplings where required to join gravity-flow, nonpressure sewer piping unless otherwise indicated.
 - a. Unshielded flexible couplings for same or minor difference OD pipes.
 - b. Unshielded, increaser/reducer-pattern, flexible couplings for pipes with different OD.
 - c. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.
 - 2. Use pressure-type pipe couplings for force main joints.

3.14 CLOSING ABANDONED STORM DRAINAGE SYSTEMS

- A. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either procedure below:
 - 1. Close open ends of piping with at least 200 mm (8 inch thick, brick masonry bulkheads.
 - 2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.
- B. Abandoned Manholes and Structures: Excavate around manholes and structures as required and use one procedure below:
 - 1. Remove manhole or structure and close open ends of remaining piping.
 - 2. Remove top of manhole or structure down to at least 900 mm (36 inches) below final grade. Fill to within 300 mm (12 inches) of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.
- C. Backfill to grade according to Section 31 20 00, EARTH MOVING.

3.15 IDENTIFICATION

- A. Install green warning tape directly over piping and at outside edge of underground structures.

Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft-AE Project No. 22-113

33 40 00-29

01/16/24

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

3.16 FIELD QUALITY CONTROL

- A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Prior to final acceptance, provide a video record of all piping from the building to the municipal connection to show the lines are free from obstructions, properly sloped and joined.
 - 1. Submit separate reports for each system inspection.
 - 2. Defects requiring correction include the following:
 - a. Alignment: Less than full diameter of inside of pipe is visible between structures.
 - b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
 - c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
 - d. Infiltration: Water leakage into piping.
 - e. Exfiltration: Water leakage from or around piping.
 - 3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
 - 4. Reinspect and repeat procedure until results are satisfactory.

3.17 STARTUP AND TESTING

- A. Make tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.
- B. Submit separate report for each test.
- C. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
 - 1. Do not enclose, cover, or put into service before inspection and approval.
 - 2. Test completed piping systems according to requirements of authorities having jurisdiction.
 - 3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours advance notice.
 - 4. Submit separate report for each test.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

5. Air test gravity sewers. Concrete pipes conform to ASTM C924, plastic pipes conform to ASTM F1417, all other pipe material conform to ASTM C828 or ASTM C924, after consulting with pipe manufacturer. Testing of individual joints shall conform to ASTM C1103.
6. Test force main storm drainage piping. Perform hydrostatic test after thrust blocks, supports, and anchors have hardened. Test at pressure not less than 1-1/2 times the maximum system operating pressure, but not less than 1034 kPa (150 psi).
 - a. Ductile Iron Piping: Test according to AWWA C600, "Hydraulic Testing" Section.
 - b. PVC Piping: Test according to AWWA M23, "Testing and Maintenance" Chapter.
- D. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government. Leaks and loss in test pressure constitute defects that must be repaired. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.
- E. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.

3.18 CLEANING

- A. Clean interior of piping of dirt and superfluous materials. Flush with potable water.

3.19 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
- B. Components provided under this section of the specification will be tested as part of a larger system.

3.20 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for four hours to instruct each VA personnel responsible in the operation and maintenance of units.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

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Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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SECTION 33 46 13

FOUNDATION DRAINAGE

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies materials and procedures for construction of foundation drainage systems, including installation, backfill, and cleanout extensions, to a point of connection to storm sewer.

1.2 RELATED WORK

- A. Excavation, Trench Widths, Pipe Bedding, Backfill, Shoring, Sheeting, Bracing: Section 31 20 00, EARTH MOVING.
- B. Materials testing and inspection during construction: Section 01 45 29, TESTING LABORATORY SERVICES.
- C. General plumbing, protection of Materials and Equipment, and quality assurance: Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
- D. Submittals: Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA AND SAMPLES.
- E. Cathodic Protection: Section 26 42 00, CATHODIC PROTECTION.

1.3 DEFINITIONS

Subdrainage: Foundation drainage system that collects and removes subsurface or seepage water from building foundation from building to discharge pond.

1.4 ABBREVIATIONS

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. HDPE: High-density polyethylene plastic.
- C. PE: Polyethylene plastic.
- D. PVC: Polyvinyl chloride plastic.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic manholes, pipe, and fittings in direct sunlight.
- B. Protect pipe, pipe fittings, and seals from dirt and damage.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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1.6 COORDINATION

- A. Coordinate connection to storm sewer main, if approved, with the Public Agency responsible for the storm sewer system.
- B. Coordinate exterior utility lines and connections to foundation building drain.

1.7 QUALITY ASSURANCE:

- A. Products Criteria:
 - 1. When two or more units of the same type or class of materials or equipment are required, these units shall be products of one manufacturer.
 - 2. A nameplate bearing manufacturer's name or trademark, including model number, shall be securely affixed in a conspicuous place on equipment. In addition, the model number shall be either cast integrally with equipment, stamped, or otherwise permanently marked on each item of equipment.
- B. Comply with the rules and regulations of the Public Agency having jurisdiction over the connection to public storm sewer lines or the requirements for discharge of subsurface drainage.

1.8 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referred in the text by basic designation only.
- B. American Society for Testing and Materials (ASTM):
 - A48-03.....Gray Iron Castings
 - C14-07.....Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe
 - C33/C33M-11.....Concrete Aggregates
 - C443-10.....Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
 - C444-03(2009).....Perforated Concrete Pipe

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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C578-10a.....Rigid, Cellular Polystyrene Thermal Insulation

C1173-08.....Flexible Transition Couplings for Underground
Piping Systems

D448-08.....Sizes of Aggregate for Road and Bridge
Construction

D1621-10.....Standard Test Method for Compressive Properties
of Rigid Cellular Plastics

D2235-04 (2011).....Solvent Cement for Acrylonitrile-Butadiene-
Styrene (ABS) Plastic Pipe and Fittings

D2321-11.....Underground Installation of Thermoplastic Pipe
for Sewers and Other Gravity-Flow Applications

D2751-05.....Acrylonitrile-Butadiene-Styrene (ABS) Sewer
Pipe and Fittings

D3034-08.....Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe
and Fittings

D3350-10a.....Polyethylene Plastic Pipe and Fittings Material

D4491-99a (2009).....Test Methods for Water Permeability of
Geotextiles by Permittivity

D4716-08.....Test Method for Determining the (In-plane) Flow
Rate per Unit Width and Hydraulic
Transmissivity of a Geosynthetic Using a
Constant Head

D5926-09.....Poly (Vinyl Chloride) (PVC) Gaskets for Drain,
Waste, and Vent (DWV), Sewer, Sanitary, and
Storm Plumbing Systems

D6707-06 (2011).....Circular-Knit Geotextile for Use in Subsurface
Drainage Applications

F405-05.....Corrugated Polyethylene (PE) Pipe and Fittings

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

F477-10.....Elastomeric Seals (Gaskets) for Joining Plastic
Pipe

F667-06.....Larger Diameter Corrugated Polyethylene Pipe
and Fittings

F2648-10.....2 to 60 Inch Annular Corrugated Profile Wall
Polyethylene (PE) Pipe and Fittings for Land
Drainage Applications

1.9 WARRANTY

The Contractor shall remedy any defect due to faulty material or workmanship and pay for any damage to other work resulting therefrom within a period of one year from final acceptance. Further, the Contractor will furnish all manufacturer's and supplier's written guarantees and warranties covering materials and equipment furnished under this Contract.

PART 2 - PRODUCTS

2.1 FACTORY-ASSEMBLED PRODUCTS

- A. Standardization of components shall be maximized to reduce spare part requirements.
- B. Contractor shall guarantee performance of assemblies of components, and shall repair or replace elements of the assemblies as required to deliver specified performance of the complete assembly.

2.2 COMPATIBILITY OF RELATED EQUIPMENT

Equipment and materials installed shall be compatible in all respects with other items being furnished and with existing items so that the result will be a complete and fully operational system that conforms to contract requirements.

2.3 UNDERSLAB HEADER

- A. PE pipe and fittings per ASTM F2648 or ASTM F2678.
- B. PVC sewer pipe and fittings per ASTM D3034, with ASTM F477, elastomeric seal gaskets.

Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft-AE Project No. 22-113

32 46 13-4

01/16/24

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

2.4 PERFORATED-WALL PIPES AND FITTINGS FOR VAULTS OR MANHOLES

A. Perforated PE Pipe and Fittings:

1. Pipe shall be ASTM D2648 or ASTM F667, Type CP; corrugated, for coupled joints.
2. Couplings: Manufacturer's standard.

B. Perforated PVC Sewer Pipe and Fittings shall be ASTM D3034.

C. Perforated Concrete Pipe and Fittings: ASTM C444, Type 1, and applicable requirements in ASTM C14, Class 2, socket-and-spigot ends for gasketed joints.

1. Gaskets: ASTM C443, rubber.

2.5 SOLID-WALL PIPES AND FITTINGS

A. ABS Sewer Pipe and Fittings shall meet ASTM D2751.

1. Solvent Cement: ASTM D2235.
2. Gaskets: ASTM F477.

B. PE Pipe and Fittings: ASTM D3350 or F405.

C. PVC Sewer Pipe and Fittings: ASTM D3034.

1. Gaskets: ASTM F477.

2.6 SPECIAL PIPE COUPLINGS

A. Comply with ASTM C1173 for joining underground non-pressure piping. Include ends of same sizes as piping to be joined and corrosion-resistant metal tension band and tightening mechanism on each end.

1. Sleeve Materials:
 - a. For Dissimilar Pipes: ASTM D5926, PVC or other material compatible with pipe materials being joined.
2. Unshielded Flexible Couplings: Elastomeric sleeve with stainless-steel shear ring and corrosion-resistant metal tension band and tightening mechanism on each end.

2.7 CLEANOUTS

A. Cleanouts: Cast-iron parts shall conform to ASTM A48. Lid shall be secured, scoriated, Medium Loading class. Include cast-iron ferrule and countersunk, brass cleanout plug.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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B. Cleanout PVC Extension shall conform to ASTM D3034. PVC extensions shall have watertight joints and long sweep elbow fittings. PVC cleanout shall have threaded plug and threaded pipe hub.

2.8 DRAINAGE CONDUITS

A. Molded-Sheet Drainage Conduits shall be prefabricated geocomposite with cusped, molded-plastic drainage core wrapped in geotextile filter fabric.

1. Nominal Size: 12 inches (305 mm) high by approximately 1 inch (25 mm) thick.

a. Minimum In-Plane Flow: 30 gpm (114 L/min.) at hydraulic gradient of 1.0 percent when tested according to ASTM D4716.

2. Filter Fabric shall conform to ASTM D6707.

3. Fittings shall be as per manufacturer.

B. Multi-pipe Drainage Conduits shall be prefabricated geocomposite with interconnected, corrugated, perforated-pipe core molded from HDPE and wrapped in geotextile filter fabric.

1. Nominal Size shall be 6 inches (152 mm) high by approximately 1-1/4 inches (31 mm) thick.

a. Minimum In-Plane Flow shall be 15 gpm (57 L/min.) at hydraulic gradient of 1.0 percent when tested according to ASTM D4716.

2. Filter Fabric shall be nonwoven geotextile.

3. Fittings shall be as per manufacturer.

4. Couplings shall be as per manufacturer.

C. Mesh Fabric Drainage Conduits shall be prefabricated geocomposite with plastic-filament drainage core wrapped in geotextile filter fabric. Include manufacturer's fittings for bends and connection to drainage piping.

1. Nominal Size shall be 6 inches (150 mm) high by approximately 0.9 inch (23 mm) thick.

a. Minimum In-Plane Flow shall be 2.4 gpm (9.1 L/min.) at hydraulic gradient of 1.0 percent when tested according to ASTM D4716.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

2. Filter Fabric shall be nonwoven geotextile. Flow rates range from 120 to 200 gpm/sq. ft. (81 to 136 L/s per sq. m) when tested according to ASTM D4491.

D. Ring Fabric Drainage Conduits shall be drainage conduit with HDPE-rings-in-grid-pattern drainage core, for field-applied geotextile filter fabric. Include manufacturer's fittings for bends and connection to drainage piping.

1. Nominal Size shall be 20 inches (0.5 m) high by 1 inch (25 mm) thick.

a. Minimum In-Plane Flow shall be 82 gpm (310 L/min.) at hydraulic gradient of 1.0 percent when tested according to ASTM D4716.

2. Filter Fabric shall be nonwoven geotextile.

E. Smooth PVC Drainage Conduits shall have perforated fittings and couplings complying with ASTM D3034.

1. Nominal size shall be 8 inches (200 mm).

a. Minimum flow rate equal to a NPS 4 (DN 100) pipe.

2. Fittings shall be as per manufacturer.

2.9 DRAINAGE MAT

Drainage mat shall be formed three dimensional polyethylene or high-impact polymeric core or compression-resistant nylon matting of open three-dimensional construction.

2.10 SOIL MATERIALS

A. Drainage Material

1. Bedding shall be crushed stone, 3/4 inch (20 mm) to No. 4 per ASTM D448, at a minimum or as per geotechnical recommendations.

2. Fill to 1 foot (300 mm) above pipe shall be Crushed stone, 3/4 inch (20 mm) to No. 4 per ASTM D448, at a minimum or as per geotechnical recommendations.

B. Concrete Sand shall be ASTM C33.

2.11 GEOTEXTILE FILTER FABRICS

A. Geotextile fabric shall conform to ASTM 6707. Elongation will be greater than 50 percent and the flow rate shall range from 110 to 330 gpm/sq. ft. (4480 to 13440 L/min. per sq. m).

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

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1. Structure Type shall be Nonwoven, needle-punched continuous filament or woven, monofilament or multifilament.
2. Style(s) shall be Flat and sock.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces and areas for suitable conditions where subdrainage systems are to be installed.
- B. If subdrainage is required for landscaping, locate and mark existing utilities, underground structures, and aboveground obstructions before beginning installation and avoid disruption and damage of services.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PIPING APPLICATIONS

- A. Underground Subdrainage Piping shall be:
 1. Perforated PVC sewer pipe and fittings for loose, bell-and-spigot joints.
- B. Underslab Subdrainage Piping shall be:
 1. Perforated PVC sewer pipe and fittings and loose, bell-and-spigot joints.
- C. Header Piping shall be:
 1. PVC sewer pipe and fittings, couplings, and coupled joints.

3.3 CLEANOUT APPLICATIONS

- A. In Underground Subdrainage Piping:
 1. At Grade in Earth shall be PVC cleanouts.
 2. At Grade in Paved Areas shall be Cast-iron cleanouts.
- B. In Underslab Subdrainage Piping:
 1. In Equipment Yards and Unfinished Areas shall be Cast-iron cleanouts.

3.4 FOUNDATION DRAINAGE INSTALLATION

- A. Place impervious fill material on subgrade adjacent to bottom of footing after concrete footing forms have been removed. Place and compact

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

impervious fill to dimensions indicated, but not less than 6 inches (150 mm) deep and 12 inches (300 mm) wide.

- B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
- C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).
- D. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape and install drainage piping.
- E. Add drainage course to width of at least 6 inches (150 mm) on side away from wall and to top of pipe to perform tests.
- F. After satisfactory testing, cover drainage piping to width of at least 6 inches (150 mm) on side away from footing and above top of pipe to within 12 inches (300 mm) of finish grade.
- G. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.
- H. Place layer of flat-style geotextile filter fabric over top of drainage course, overlapping edges at least 4 inches (100 mm).
- I. Install vertical drainage panels as follows:
 - 1. Coordinate placement with other drainage materials.
 - 2. Lay perforated drainage pipe at base of footing. Do not install aggregate.
 - 3. Separate 4 inches (100 mm) of fabric at beginning of roll and cut away 4 inches (100 mm) of core. Wrap fabric around end of remaining core.
 - 4. Wrap bottom of panel around drainage pipe.
 - 5. Attach panel to wall at horizontal mark and at beginning of pipe. Place core side of panel against wall. Use concrete nails with washers through product cylinders to attach panel to wall. Place nails from 2 to 6 inches (50 to 150 mm) below top of panel, approximately 48 inches (1200 mm) apart. Do not penetrate

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Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

waterproofing. Before using adhesives, discuss with waterproofing manufacturer.

6. If additional panels are required on same row, cut away 4 inches (100 mm) of installed panel core, install new panel against installed panel, and overlap new panel with installed panel fabric.
7. If additional rows of panels are required, overlap lower panel with 4 inches (100 mm) of fabric.
8. Cut panel as necessary to keep top 12 inches (300 mm) below finish grade.
9. For inside corners, bend panel. For outside corners, cut core to provide 3 inches (75 mm) for overlap.
- J. Do not use drainage panels as protection for waterproof membrane unless approved by factory-authorized service representative of waterproofing membrane manufacturer. Submit approval if so used.
- K. Place initial backfill material over compacted drainage course. Place material in loose-depth layers not exceeding 6 inches (150 mm). Thoroughly compact each layer. Final backfill to finish elevations and slope away from building.

3.5 UNDERSLAB DRAINAGE INSTALLATION

- A. Excavate for underslab drainage system after subgrade material has been compacted but before drainage course has been placed. Include horizontal distance of at least 6 inches (150 mm) between drainage pipe and trench walls. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.
- B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
- C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).
- D. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape. Install drainage piping.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

- E. Add drainage course to width of at least 6 inches (150 mm) on side away from wall and to top of pipe to perform tests.
- F. After satisfactory testing, cover drainage piping with drainage course to elevation of bottom of slab, and compact and wrap top of drainage course with flat-style geotextile filter fabric.
- G. Install horizontal drainage panels as follows:
 - 1. Coordinate placement with other drainage materials.
 - 2. Lay perforated drainage pipe at inside edge of footings.
 - 3. Place drainage panel over drainage pipe with core side up. Peel back fabric and wrap fabric around pipe. Locate top of core at bottom elevation of floor slab.
 - 4. Butt additional panels against other installed panels. If panels have plastic flanges, overlap installed panel with flange.

3.6 PLAZA DECK DRAINAGE INSTALLATION

Horizontal Drainage Panel shall be installed between slab and floor cover. Place core on structural floor. Install panels to fit tightly around floor drains of building's storm drainage system. Provide stormwater access into floor drain.

3.7 RETAINING-WALL DRAINAGE INSTALLATION

- A. Place supporting layer of drainage course over compacted subgrade to compacted depth of not less than 4 inches (100 mm).
- B. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape. Install drainage piping.
- C. Add drainage course to width of at least 6 inches (150 mm) on side away from wall and to top of pipe to perform tests.
- D. After satisfactory testing, cover drainage piping to width of at least 6 inches (150 mm) on side away from footing and above top of pipe to within 12 inches (300 mm) of finish grade.
- E. Place drainage course in layers not exceeding 3 inches (75 mm) in loose depth; compact each layer placed and wrap top of drainage course with flat-style geotextile filter fabric.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

F. Place layer of flat-style geotextile filter fabric over top of drainage course, overlapping edges at least 4 inches (100 mm).

G. Install vertical drainage panels as follows:

1. Coordinate placement with other drainage materials.
2. Lay perforated drainage pipe at base of footing. Do not install aggregate.
3. Mark horizontal chalk line on wall at a point 6 inches (150 mm) less than panel width above footing bottom. Before marking wall, subtract footing width.
4. Separate 4 inches (100 mm) of fabric at beginning of roll and cut away 4 inches (100 mm) of core. Wrap fabric around end of remaining core.
5. Wrap bottom of panel around drainage pipe.
6. Attach panel to wall at horizontal mark and at beginning of wall corner. Place core side of panel against wall. Use concrete nails with washers through product. Place nails from 2 to 6 inches (50 to 150 mm) below top of panel, approximately 48 inches (1200 mm) apart. Construction adhesives, metal stick pins, or double-sided tape may be used instead of nails. Do not penetrate waterproofing. Before using adhesives, discuss with waterproofing manufacturer.
7. If another panel is required on same row, cut away 4 inches (100 mm) of installed panel core and wrap fabric over new panel.
8. If additional rows of panel are required, overlap lower panel with 4 inches (100 mm) of fabric.
9. Cut panel as necessary to keep top 12 inches (300 mm) below finish grade.
10. For inside corners, bend panel. For outside corners, cut core to provide 3 inches (75 mm) for overlap.
11. Do not use drainage panels as protection for waterproof membrane unless approved by factory-authorized service representative of waterproofing membrane manufacturer. Submit approval if so used.

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

H. Fill to Grade: Place satisfactory soil fill material over compacted drainage course. Place material in loose-depth layers not exceeding 6 inches (150 mm). Thoroughly compact each layer. Fill to finish grade.

3.8 LANDSCAPING DRAINAGE INSTALLATION

- A. Provide trench width to allow installation of drainage conduit. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.
- B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
- C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).
- D. Install drainage conduits with horizontal distance of at least 6 inches (150 mm) between conduit and trench walls. Wrap drainage conduits without integral geotextile filter fabric with flat-style geotextile filter fabric before installation. Connect fabric sections with adhesive or tape.
- E. Add drainage course to top of drainage conduits.
- F. After satisfactory testing, cover drainage conduit to within 12 inches (300 mm) of finish grade.
- G. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.
- H. Place layer of flat-style geotextile filter fabric over top of drainage course, overlapping edges at least 4 inches (100 mm).
- I. Fill to Grade: Place satisfactory soil fill material over drainage course. Place material in loose-depth layers not exceeding 6 inches (150 mm). Thoroughly compact each layer. Fill to finish grade.

3.9 PIPING INSTALLATION

- A. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing in filtering material. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions and other requirements indicated.

Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft-AE Project No. 22-113

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

1. Foundation Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 0.5 percent and with a minimum cover of 36 inches (915 mm), unless otherwise indicated.
 2. Underslab Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 0.5 percent.
 3. Landscaping Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 0.5 percent and with a minimum cover of 36 inches (915 mm), unless otherwise indicated.
 4. Lay perforated pipe with perforations down.
 5. Excavate recesses in trench bottom for bell ends of pipe. Lay pipe with bells facing upslope and with spigot end entered fully into adjacent bell.
- B. Use increasers, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.
- C. Install PVC piping according to ASTM D2321.

3.10 PIPE JOINT CONSTRUCTION

- A. Cast-Iron Soil Pipe and Fittings: Hub and spigot, with rubber compression gaskets according to ASTM A74. Use gaskets that match class of pipe and fittings.
- B. Join ABS pipe and fittings according to ASTM D2751.
- C. Join PE pipe or perforated PE pipe, tubing, and fittings with couplings for soil-tight joints according to ASTM D2321.
- D. Join PVC pipe and fittings according to ASTM D2729.
- E. Join perforated PVC pipe and fittings according to ASTM D2729.
- F. Join perforated concrete pipe and fittings with gaskets according to ASTM C443.
- G. Special Pipe Couplings: Join piping made of different materials and dimensions with special couplings made for this application. Use couplings that are compatible with and fit materials and dimensions of both pipes.

3.11 CLEANOUT INSTALLATION

- A. Cleanouts for Foundation and Landscaping Subdrainage:

Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft-AE Project No. 22-113

32 46 13-14

01/16/24

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

1. Install cleanouts from piping to grade. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
2. In vehicular-traffic areas, use NPS 4 (DN 100) cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, 18 by 18 by 12 inches (450 by 450 by 300 mm) in depth. Set top of cleanout flush with grade. Cast-iron pipe may also be used for cleanouts in nonvehicular-traffic areas.
3. In nonvehicular-traffic areas, use NPS 4 (DN 100) PVC pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, 12 by 12 by 4 inches (300 by 300 by 100 mm) in depth. Set top of cleanout plug 1 inch (25 mm) above grade.

B. Cleanouts for Underslab Subdrainage:

1. Install cleanouts and riser extensions from piping to top of slab. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
2. Use NPS 4 (DN 100) cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout flush with top of slab.

3.12 CONNECTIONS

- A. Connect low elevations of subdrainage system to solid-wall-piping storm drainage system.

3.13 IDENTIFICATION

- A. Install PE warning tape or detectable warning tape over ferrous piping.
- B. Install detectable warning tape over nonferrous piping and over edges of underground structures.

3.14 FIELD QUALITY CONTROL

Testing: After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.

Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft-AE Project No. 22-113

Fargo VA Health Care Systems
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades-Tier 2

Bancroft Architects + Engineers

3.15 CLEANING

Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

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DIVISION 34

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

08-01-16

SECTION 34 75 13.13
ACTIVE VEHICLE BARRIERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Active anti-ram rated vehicle barriers at entrances.

1.2 RELATED REQUIREMENTS

- A. Barrier Foundations: Section 03 30 00, CAST-IN-PLACE CONCRETE.
- B. Barrier Color: Section 09 06 00, SCHEDULE FOR FINISHES.
- C. Electrical Power and Control Wiring: Division 26, ELECTRICAL.
- D. Facility Access Control: Section 28 13 00, PHYSICAL ACCESS CONTROL SYSTEMS.
- E. Facility Access Control Software: Section 28 13 16, PHYSICAL ACCESS CONTROL SYSTEM AND DATABASE MANAGEMENT.
- F. Intrusion Detection: Section 28 16 00, INTRUSION DETECTION SYSTEM.
- G. Vehicular Paving and Curbs: Section 32 05 23, CEMENT AND CONCRETE FOR EXTERIOR IMPROVEMENTS.

1.3 APPLICABLE PUBLICATIONS

- A. Comply with references to extent specified in this section.
- B. American Welding Society (AWS):
 1. D1.1/D1.1M-15 - Structural Welding Code - Steel.
- C. ASTM International (ASTM):
 1. D1187/D1187M-97(2011)e1 - Asphalt-Base Emulsions for Use as Protective Coatings for Metal.
 2. A123/A123M-15 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 3. A514/A514M-14 - High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding.
 4. F2200-14 - Automated Vehicular Gate Construction.
 5. F2656/F2656M-15 - Crash Testing of Vehicle Security Barriers.
- D. British Standards (BS):

Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft-AE Project No. 22-113

1/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

08-01-16

1. EN 10294-2-12 - Hollow Bars for Machining. Technical Delivery Conditions. Non Alloy and Alloy Steels.
- E. International Electrotechnical Commission (IEC):
 1. 60529-13 - Degrees of Protection Provided By Enclosures (IP Code).
- F. Master Painters Institute (MPI):
 1. No. 18 - Primer, Zinc Rich, Organic.
- G. National Electrical Manufacturers Association (NEMA):
 1. MG 1-14 - Motors and Generators.
- H. UL LLC (UL):
 1. Listed - Online Certifications Directory.
- I. United States Army Corps of Engineers (USACE):
 1. DOD Anti-Ram Vehicle Barrier List.
- J. United States Department of State (DS):
 1. SD-STD02.01-Revision A - Vehicle Crash Testing of Perimeter Barriers and Gates.

1.4 PREINSTALLATION MEETINGS

- A. Conduct preinstallation meeting minimum 30 days before beginning Work of this section.
 1. Required Participants:
 - a. Contracting Officer's Representative.
 - b. Contractor.
 - c. Installer.
 - d. Other installers responsible for adjacent and intersecting work, including foundation, electrical system, security system and paving installers.
 2. Meeting Agenda: Distribute agenda to participants minimum 3 days before meeting.
 - a. Installation schedule.
 - b. Installation sequence.
 - c. Preparatory work.
 - d. Protection before, during, and after installation.
 - e. Installation.
 - f. Utility connections.
 - g. Inspecting and testing.

Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft-AE Project No. 22-113

1/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

08-01-16

- h. Other items affecting successful completion.
- 3. Document and distribute meeting minutes to participants to record decisions affecting installation.

1.5 SUBMITTALS

- A. Submittal Procedures: Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Submittal Drawings:
 - 1. Show size, configuration, and fabrication and installation details.
 - 2. Show dimensions and clearances between barriers and other adjacent permanent construction.
 - 3. Show interconnecting piping between system components.
 - 4. Show power and control wiring diagrams and routing between system components.
 - 5. Include setting drawings and templates for anchors, sleeves, and other items embedded into concrete foundations.
- C. Manufacturer's Literature and Data:
 - 1. Description of each product.
 - 2. Current product listing on USACE Department of Defense Anti-Ram Vehicle Barrier List.
 - 3. Installation instructions.
 - 4. Warranty.
- D. Samples:
 - 1. Bollard: Full sized, complete assembly including selected finish.
 - 2. Approved samples may be incorporated into work.
- E. Test reports: Certify each product complies with specifications.
 - 1. Show ram resistance rating.
- F. Certificates: Certify each product complies with specifications.
 - 1. Show electrical components are UL Listed for specified application.
 - 2. Submit factory service representative installation certification.
- G. Qualifications: Substantiate qualifications comply with specifications.
 - 1. Manufacturer with project experience list.
 - 2. Installer with project experience list.
 - 3. Welders and welding procedures.
- H. Operation and Maintenance Data:

Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft-AE Project No. 22-113

1/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

08-01-16

1. Care instructions for each exposed finish product.
2. Start-up, maintenance, troubleshooting, emergency, and shut-down instructions for each operational product.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Regularly manufactures specified products.
2. Manufactured specified products with satisfactory service on five similar installations for minimum five years.
 - a. Project Experience List: Provide contact names and addresses for completed projects.

B. Installer Qualifications: Product manufacturer.

1. Regularly installs specified products.
2. Installed specified products with satisfactory service on five similar installations for minimum five years.
 - a. Project Experience List: Provide contact names and addresses for completed projects.

C. Welders and Welding Procedures Qualifications: AWS D1.1/D1.1M.

1.7 FIELD CONDITIONS

A. Field Measurements: Verify field conditions affecting vehicle barrier fabrication and installation. Show field measurements on Submittal Drawings.

1. Coordinate field measurement and fabrication schedule to avoid delay.

1.8 WARRANTY

A. Construction Warranty: FAR clause 52.246-21, "Warranty of Construction."

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Vehicle Barrier System: Device listed in USACE DOD Anti-Ram Vehicle Barriers List.

1. Configuration: Drop-arms.
2. Type: Permanent.

Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft-AE Project No. 22-113

1/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

08-01-16

3. Mounting: As indicated on drawings.
4. Deployed Position: Secured, preventing vehicle passage.
5. Stored Position: Unsecured, allowing vehicle passage.

2.2 SYSTEM PERFORMANCE

- A. Design active vehicle barrier complying with specified performance:
 1. Ram Resistance: ASTM F2656 or DS SD-STD02.01 rated to stop 1,800 kg (4,000 lb.) vehicle traveling 48 km/hr. (30 mph) on impact.
 2. Dynamic Penetration Resistance: P1.

2.3 PRODUCTS - GENERAL

- A. Provide each product from one manufacturer.
- B. Electrical Components: UL Listed to suit application.

2.4 FINISHES

- A. Steel Paint Finish:
 1. Manufacturer's standard industrial enamel finish system.
 - a. One coat primer.
 - b. One or more finish coats.
 - c. Color: Refer to Section 09 06 00, SCHEDULE FOR FINISHES.
- B. Aluminum Paint Finish:
 1. Manufacturer's standard industrial enamel finish system.
 - a. One coat primer.
 - b. One or more finish coats.
 - c. Color: Refer to Section 09 06 00, SCHEDULE FOR FINISHES.
- C. Finish exposed surfaces after fabrication.

2.5 ACCESSORIES

- A. Barrier Coating: ASTM D1187/D1187M.
- B. Welding Materials: AWS D1.1/D1.1M, type to suit application.
- C. Anchors: Manufacturer's standard, corrosion resistant, to suit application.
- D. Galvanizing Repair Paint: MPI No. 18.
- E. Touch-Up Paint: Match shop finish.

Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft-AE Project No. 22-113

1/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

08-01-16

PART 3 - EXECUTION

3.1 PREPARATION

- A. Examine and verify foundation suitability for product installation.
- B. Coordinate delivery and installation of anchors, sleeves, and other items embedded in concrete foundations.
- C. Coordinate barrier system layout and installation with connections to power supplies, perimeter security system, and security access control system.
- D. Apply barrier coating to steel surfaces in contact with dissimilar metals and cementitious materials to minimum 0.7 mm (30 mils) dry film thickness.

3.2 INSTALLATION

- A. Install products according to manufacturer's instructions and approved submittal drawings.
 - 1. When manufacturer's instructions deviate from specifications, submit proposed resolution for Contracting Officer's Representative consideration.
- B. Anchor barriers to foundations.
- C. Connect electrical power and control wiring.
- D. Touch up damaged factory finishes.
 - 1. Repair galvanized surfaces with galvanized repair paint.
 - 2. Repair painted surfaces with touch up primer.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer Services:
 - 1. Provide factory service representative to inspect and adjust barriers.
 - 2. Certify installation complies with manufacturer's instructions.

3.4 ADJUSTING AND CLEANING

- A. Clean exposed barrier surfaces. Remove contaminants and stains.
- B. Adjust barriers to operate smoothly, easily, and properly. Confirm locks engage accurately and securely without forcing or binding.
- C. Lubricate hardware and other moving parts.

Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft-AE Project No. 22-113

1/16/2024

Fargo VA Health Care System
Fargo, North Dakota 58102-2417
EHRM Infrastructure Upgrades - Tier 2

Bancroft Architects + Engineers

08-01-16

3.5 DEMONSTRATION AND TRAINING

- A. Instruct VA personnel in proper barrier operation and maintenance.
 - 1. Trainer: Manufacturer approved instructor.
 - 2. Training Time: Four hours minimum.
- B. Acceptance Condition: After completing work, operate barriers 15 consecutive calendar days without breakdown.

3.6 PROTECTION

- A. Protect barriers from traffic and construction operations.
 - 1. Remove and store barrier gate arms to prevent damage from construction operations.
 - 2. Reinstall barrier gate arms immediately before Substantial Completion.
- B. Remove protective materials immediately before acceptance.
- C. Repair damage.

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Contract No. 36C26319D0044
Station Project No. 437-210
Bancroft-AE Project No. 22-113

1/16/2024

