

SECTION 3

TECHNICAL PROVISIONS

TABLE OF CONTENTS

<u>SECTION</u>	<u>TITLE</u>
01000	SCOPE OF WORK
02205	REMOVAL AND RESTORATION OF EXISTING FACILITIES
02225	SELECTIVE DEMOLITION
03900	MINOR REPAIRS TO EXISTING CONCRETE
04050	MORTAR, GROUT AND MASONRY ACCESSORIES
04220	CONCRETE UNIT MASONRY
05120	STRUCTURAL STEEL
05500	MISCELLANEOUS METALS
08305	ACCESS DOORS AND FRAMES
08710	FINISH HARDWARE
09920	FIELD PAINTING
15050	BASIC MECHANICAL MATERIALS AND METHODS
15055	COMMON MOTORS & MOTOR CONTROLLER REQUIREMENTS FOR HVAC EQUIPMENT
15060	HANGERS AND SUPPORTS
15070	VIBRATION ISOLATION
15075	MECHANICAL IDENTIFICATION
15080	INSULATION
15185	HYDRONIC PUMPS
15186	WATER TREATMENT SYSTEM
15205	PIPING SYSTEMS
15625A	WATER COOLED CENTRIFUGAL CHILLERS
15635	REFRIGERANT MONITORING AND SAFETY EQUIPMENT
15733A	AIR CONDITIONING UNITS – CHILLED WATER COOLED
15815	METAL DUCTS
15820	DUCT ACCESSORIES
15900	HVAC INSTRUMENTATION AND CONTROLS
15950	SYSTEM BALANCING AND TESTING
16050	BASIC ELECTRICAL MATERIALS AND METHODS
16060	GROUNDING AND BONDING
16120	WIRE AND CABLE
16125	WIRE CONNECTION ACCESSORIES
16130	RACEWAYS AND BOXES
16425	MOTOR STARTERS
16440	CIRCUIT BREAKERS
16601	AUTOMATED ENERGY MANAGEMENT SYSTEM

SECTION 01000

SCOPE OF WORK

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. This section specifies the furnishing and installation of the Chillers at CHPC1 Metro Center, CHPC5 Crystal City and CHPD3 Potomac Avenue chiller plant locations. The Contractor shall furnish all labor, tools, materials, transportation, and other items necessary to satisfactorily complete this Project as written in the Specifications and as indicated on the Contract Drawings.
- B. Particulars include but are not limited to the following:
 - 1. Contractor shall be responsible for all permits and inspections. Contractor shall comply with Federal and jurisdictional requirements and codes pertaining to this Project. Contractor shall also comply with all safety requirements and permits required by WMATA.
 - 2. **CHPC1 – METRO CENTER CHILLER PLANT REPLACEMENT**
 - (a) Remove and dispose one chiller plant exhaust fan. Removal shall include the fan, motor, ductwork, support, starter, wiring, disconnect, all AEMS sensors, and controls. Remove existing louver, fire damper and enlarge wall opening in order to receive new louver.
 - (b) Remove and dispose of controls for chilled water air handling units. Removal shall include all applicable AEMS sensors, and controls.
 - (c) Remove and dispose of two water cooled chillers as indicated on drawing. Removal shall include the chiller, chiller supports, starter, wiring, disconnects, all applicable AEMS sensors, and controls.
 - (d) Removal of the chiller shall also include R-134A refrigerant evacuation and recovery performed according to Federal and jurisdictional requirements. Submit to WMATA: Certifications of the company handling and recycling R-134A Refrigerant. Contractor upon evacuating and recovering the refrigerant, the refrigerant shall be cleansed and returned to WMATA. If WMATA decides the R-134A Refrigerant should change ownership, submit to WMATA documents certifying transfer of refrigerant ownership.
 - (e) Remove and dispose of chilled water pumps #7 and #8 and condenser water pump #3 and #4. Removal shall include the pumps, pump motors, pump supports, vibration isolators, immediate piping and valves, starter, wiring, disconnects, all AEMS sensors, and controls, if applicable.
 - (f) Remove and salvage six cooling tower fan motors, belt drives and related starters and controls. Modify existing cooling tower Control Panel to adopt the new variable frequency drive controller. The frequency drive controllers shall be installed adjacent to the cooling towers on roof.
 - (g) Remove and dispose of two sets, abandoned tower water treatment components. Existing condenser water treatment is to remain.
 - (h) Provide and install two new water cooled chillers. Installation shall include all related pipe fittings, valves, insulation, vibration isolation, unit mounted starter and variable frequency drives, disconnects, conduit, wiring, and controls.
 - (i) Replace six belt-driven fan drive assembly with direct driven assembly and mounting

hardware for four Cooling Towers.

- (j) Replace the motors of six Cooling Tower fans. Six motors shall be inverter type to match the new variable frequency drive controllers.
- (k) Provide and install chilled water pumps #7 and #8 and condenser water pumps #3 and #4. New installation shall include the pumps, inverter rated motors, pump supports, vibration isolators, immediate piping, flexible connectors and valves and controls.
- (l) Provide and install two chilled water pump motor variable frequency drives, four condenser water pump motor variable frequency drives, and six cooling tower fan motor variable frequency drives including disconnects, conduit, power and control wiring.
- (m) Integrate pump and tower fan variable frequency drives with the chiller control systems. Pump control features shall include soft-start and off modes. Frequency adjustment for pump motors shall be used for initial flow balancing and shall not be varied during normal operation. Tower fan control features shall include soft-start, load modulation, and off modes. Modulation will be controlled by chiller mounted condenser water temperatures.
- (n) Provide and install two chiller plant exhaust fans. System shall include the fans, motors, ductwork, supports, starters, wiring, disconnects, all sensors and controls. Provide new louver, motorize dampers and fire damper. Patch wall opening to match existing after installing new louver. Exact size of louver and wall opening shall be directed by AR after coordinating with building owner.
- (o) Provide and install two new AEMS sensors and controls for existing chilled water air handling units
- (p) Provide and install (2-sets) chilled water treatment systems: (1-set) for Chiller #3 & 4 which are to be replaced under this contract and the other set for the existing Chiller #1 & 2. Each set of chilled water treatment system shall include piping, chemical sensors, and controls. Sensors shall include; Hach Inductive Conductivity Sensor -3725E2T; Sensor module for conductivity – 9013000 and a convertible Digital Differential pH Sensor product number DPC1R2A. Two HACH SC200 Controllers shall be installed to accept the input probes and control the chemical injection. Controller shall include a RS485 communications card.
- (q) Provide (2) Chiller Plant Monitoring Panels for Chiller #3 & 4 and for Chiller #1 & 2. Each Chiller Plant Monitoring Panel shall include Automatic Direct Productivity 3000 PAC Controller, Modbus capable Input and Output Cards, etc. as indicated in the Contract Drawings.
- (r) Provide and install refrigerant detection for new and existing chiller and alarm system and interface with exhaust fans.
- (s) Provide and install two chilled water and two condenser water flow monitoring systems.
- (t) Provide and install outdoor air temperature and relative humidity and inside temperature sensors and interface with Chiller Plant Monitoring Panel; Automation Direct Productivity 3000 PAC. Contractor to install P3-08RTD input module in Productivity 3000 PAC to accept input from RTD temperature sensors.
- (u) Provide and install any other equipment and components required by chiller and cooling tower manufacturers to ensure a satisfactory performance of the manufacturer's system.
- (v) Provide and install new ModBus communication cards and control, Microtech II, on new/replacement chiller to allow for remote monitoring and control of equipment.
- (w) Repair and modify existing housekeeping pads as needed for replacement chiller and pumps.
- (x) Remove rust and paint the cooling tower support/ steel framing on roof and the Condenser water pipe. See specification section 09920.
- (y) Provide spring type, vibration isolators for chillers, pumps and air handling units and the ceiling hung exhaust fans.

- (z) Provide Maintenance and Repair and Testing and Operations manuals for all systems and components, individually for each location.
- (aa) Provide field survey service, and as-built drawings including new and existing to Remain in the chiller plant and the associated piping and ventilation system, Drawing shall include plans, at least 2-sections and isometric views of the piping system.
- (bb) Train WMATA personnel on system operations and maintenance.
- (cc) Test and Balance the water system in accordance with NEBB or AABC.

3. CHPC5 - CRYSTAL CITY CHILLER PLANT REPLACEMENT

- (a) Remove and dispose two chiller plant exhaust fans. Removal shall include the fans, motors, ductwork as indicated on drawings, supports, starters, wiring, disconnects, all AEMS sensors and controls.
- (b) Remove and dispose of one water-cooled chiller as indicated on drawing. Removal shall include the chiller, chiller supports, starter, wiring, disconnects, all AEMS sensors, and controls.
- (c) Removal of the chiller shall also include R-134A refrigerant evacuation and recovery performed according to Federal and jurisdictional requirements. Submit to WMATA: Certifications of the company handling and recycling R-134A Refrigerant. Contractor upon evacuating and recovering the refrigerant, the refrigerant shall be cleansed and returned to WMATA. If WMATA decides the R-134A Refrigerant should change ownership, submit to WMATA documents certifying transfer of refrigerant ownership.
- (d) Remove and dispose chilled water pumps #1 and #2 and condenser water pump #3 and #4. Removal shall include the pumps, pump motors, pump supports, vibration isolators, immediate piping and valves, starter, wiring, disconnects, all AEMS sensors, and controls, if applicable. Remove existing flow/control sensor for condenser water supply.
- (e) Remove and salvage one cooling tower fan motor and related starters and controls. Modify existing cooling tower Control Panel to adopt the new variable frequency drive controller which is installed at the Chiller Plant Room.
- (f) Remove and dispose of abandoned tower water treatment components at cooling tower. Existing condenser water treatment system is to remain.
- (g) Provide and install one new water cooled chiller. Installation shall include all related pipe fittings, valves, insulation, vibration isolation, unit mounted starter, disconnects, conduit, wiring, and controls.
- (h) Provide and install one cooling tower inverter-rated fan motor.
- (i) Replace the belt-driven fan drive assembly with direct driven assembly and mounting hardware for the Cooling Tower.
- (j) Replace the motor of the Cooling Tower fan. Motor shall be inverter type to match the variable frequency drive controller.
- (k) Provide and install chilled water pumps #1 and #2 and condenser water pump #3 and #4. New installation shall include the pumps, inverter rated motors, pump supports, vibration isolators, immediate piping, flexible connectors and valves, and controls.
- (l) Provide and install two chilled water pump motor variable frequency drives, two condenser water pump motor variable frequency drives, and one cooling tower fan motor variable frequency drive including disconnects, conduit, power and control wiring.
- (m) Integrate pump and tower fan variable frequency drives, with the chiller control systems. Pump control features shall include soft-start and off modes. Frequency adjustment for pump motors shall be used for initial flow balancing and shall not be varied during normal operation. Tower fan control features shall include soft-start, load modulation, and off modes. Modulation will be controlled by chiller mounted condenser water temperatures.
- (n) Provide and install two chiller plant exhaust fans. System shall include the fans,

motors, ductwork as indicated on drawings, supports, starters, wiring, disconnects, all sensors and controls. Coordinate with AR for the exhaust duct replacement and patch and seal air tight existing duct.

- (o) Provide and install chilled water treatment systems, including piping, chemical sensors, and controls. Sensors shall include; Hach Inductive Conductivity Sensor - 3725E2T; Sensor module for conductivity - 9013000 and a convertible Digital Differential pH Sensor product number DPC1R2A. Two HACH SC200 Controllers shall be installed to accept the input probes and control the chemical injection. Controller shall include a RS485 communications card. Provide Chiller Plant Monitoring Panel with Automatic Direct Productivity 3000 PAC Controller, Modbus capable Input and Output Cards, etc. as indicated in the Contract Drawings.
- (p) Provide and install outdoor air temperature and relative humidity and inside temperature sensors and interface with Chiller Plant Monitoring Panel; Automation Direct Productivity 3000 PAC. Contractor to install P3-08RTD input module in Productivity 3000 PAC to accept input from RTD temperature sensors.
- (q) Provide and install refrigerant detection and alarm system and interface with exhaust system.
- (r) Provide and install one chilled water and one condenser water flow monitoring system.
- (s) Provide and install chilled water air handling unit for the equipment space.
- (t) Provide and install any other equipment and components required by chiller and cooling tower manufacturers to ensure a satisfactory performance of the manufacturers' system.
- (u) Provide and install new ModBus communication cards and control, Microtech II, on replacement chiller to allow for remote monitoring and control of equipment.
- (v) Repair and modify existing housekeeping pads as needed for replacement chiller and pumps.
- (w) Remove rust, clean and paint the cooling tower support/ steel framing on roof and the Condenser water pipe. See specification section 09920.
- (x) Provide spring type, vibration isolators for chillers, pumps and air handling unit and the ceiling hung exhaust fan.
- (y) Provide Maintenance and Repair and Testing and Operations manuals for all systems and components, individually for each location.
- (z) Train WMATA personnel on system operations and maintenance.
- (aa) Test and Balance all water systems in accordance with NEBB or AABC.

4. CHPD3 - POTOMAC AVE CHILLER PLANT REPLACEMENT

- (a) Remove and dispose of two water cooled chiller as indicated on drawing. Removal shall include the chiller, chiller supports, starter, wiring, disconnects, all applicable AEMS sensors, and controls. Remove existing valves associated with chillers, clean and coordinate with AR for the reuse of existing valves. Then, re-install valves to meet the piping configuration for the new chillers.
- (b) Removal of the chiller shall also include R-134A refrigerant evacuation and recovery performed according to Federal and jurisdictional requirements. Submit to WMATA: Certifications of the company handling and recycling R-134A Refrigerant. Contractor upon evacuating and recovering the refrigerant, the refrigerant shall be cleansed and returned to WMATA. If WMATA decides the R-134A Refrigerant should change ownership, submit to WMATA documents certifying transfer of refrigerant ownership.
- (c) Remove and dispose of chilled water pumps #1 and #2. Removal shall include the pumps, pump motors, pump supports, vibration isolators, immediate piping and valves, starter, wiring, disconnects, all AEMS sensors, and controls, if applicable.
- (d) Remove and salvage two cooling tower fan motors, belt drives and related starters and controls. Modify existing cooling tower Control Panel to adopt the new variable frequency drive controller. The frequency drive controllers shall be installed adjacent to the cooling

- towers on roof. Overhaul cooling towers and replace in-kind cooling media (fill).
- (e) Remove and dispose of abandoned tower water treatment components. Existing condenser water treatment system to remain.
 - (f) Remove existing compression tank. Replace in kind.
 - (g) Provide and install two new water cooled chiller. Installation shall include all related pipe fittings, valves, insulation, vibration isolation, unit mounted starter, disconnects, conduit, wiring, and controls. Subject to AR decision, existing valves shall be re-installed.
 - (h) Replace the belt-driven fan drive assembly with direct driven assembly and mounting hardware for two Cooling Towers.
 - (i) Replace the motor of two Cooling Tower fan. Two motors shall be inverter type to match the variable frequency drive controller.
 - (j) Provide and install chilled water pumps #1 and #2. New installation shall include the pumps, inverter rated motors, pump supports, vibration isolators, immediate piping, flexible connectors and valves and controls.
 - (k) Provide and install two chilled water pump motor variable frequency drives and two cooling tower fan motor variable frequency drives including disconnects, conduit, power and control wiring.
 - (l) Integrate pump and tower fan variable frequency drives with the chiller control systems. Pump control features shall include soft-start and off modes. Frequency adjustment shall be used for initial flow balancing and shall not be varied during normal operation. Tower fan control features shall include soft-start, load modulation, and off modes. Modulation will be controlled by chiller mounted condenser water temperatures.
 - (m) Provide and install a chiller plant exhaust fan. System shall include the fans, motors, Ductwork as shown on drawing, supports, starters, wiring, disconnects, all sensors and controls. Coordinate with WMATA/ Structural Engineer for the exact roof opening for duct penetration. Patch roof opening and match existing roofing after duct installation.
 - (n) Provide and install chilled water treatment systems including piping, water chemical sensors, and controls. Water Treatment sensors shall include; Hach Inductive Conductivity Sensor - 3725E2T; Sensor module for conductivity - 9013000 and a Convertible Digital Differential pH Sensor product number DPC1R2A. Two HACH SC200 Controllers shall be installed to accept the input probes and control the chemical injection. Controller shall include a RS485 communications card.
 - (o) Provide Chiller Plant Monitoring Panel including Automatic Direct Productivity 3000 PAC Controller, Modbus capable Input and Output Cards, etc. as indicated in the Contract Drawings.
 - (p) Provide new compression tank, replace in kind.
 - (q) Coordinate with AR for the exact location of water treatment systems, and Chiller Plant Monitoring Panel not to obstruct existing windows.
 - (r) Provide and install refrigerant detection and alarm system and interface with exhaust fans.
 - (s) Provide and install one chilled water and one condenser water flow monitoring systems.
 - (t) Provide and install outdoor air temperature and relative humidity and inside air temperature sensors and interface with Chiller Plant Monitoring Panel; Automation Direct Productivity 3000 PAC. Contractor to install P3-08RTD input module in Productivity 3000 PAC to accept Input from RTD temperature sensors.
 - (u) Provide and install any other equipment and components required by chiller and cooling tower manufacturers to ensure a satisfactory performance of the manufacturer's system.
 - (v) Provide and install new ModBus communication cards and control, Microtech II, on replacement chiller to allow for remote monitoring and control of equipment.
 - (w) Remove rust and paint the cooling tower support/ steel framing on roof and the Condenser water pipe. See specification section 09920.
 - (x) Provide spring type, vibration isolators for chillers, pumps and air handling units and the ceiling hung exhaust fan.

- (y) Repair and modify existing housekeeping pads as needed for replacement chiller and pumps.
- (z) Provide Maintenance and Repair and Testing and Operations manuals for all systems and components, individually for each location.
- (aa) Train WMATA personnel on system operations and maintenance.
- (bb) Test and Balance the water system in accordance with NEBB or AABC.

1.02 QUALITY ASSURANCE

A. Qualifications of Manufacturer:

1. Equipment shall have been produced by a manufacturer of established reputation with a minimum of five years experience supplying specified equipment.
2. Minimum expected life of this equipment shall be 10 years. All equipment furnished shall be heavy duty, commercial type. Ready availability of spare and repair parts will be important criteria in evaluating manufacturer's proposals. Maintainability and ease of service are additional important evaluation criteria.
3. The AR reserves the right to inspect materials, and their sources, workmanship, and construction methods at any time, at the Manufacturer's shop or fabricating facility. The AR further reserves the right to be present for any or all shop tests of components, assemblies, or systems. Contractor shall notify the AR 2 weeks in advance of any tests.
4. The Authority shall have final approval of the equipment manufacturer.

B. Manufacturer's Representative:

1. Installation: Provide a qualified manufacturer's representative at site to supervise work related to equipment installation, check-out, and start-up operations at each location.

C. Reference Codes and Specifications:

1. Codes and regulations of the District of Columbia.
2. Code and regulations of Maryland and the Commonwealth of Virginia.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with Section 2, Special Conditions and with the additional requirements as specified for each:

1. Shop Drawings and Manufacturer's Literature:
 - (a) Show details of construction and interfacing with other trades.
 - (b) Bar graph progress and delivery schedule.
2. Design drawings for additional equipment-related structural work:
 - (a) Show details of construction and interfacing with other trades.
3. Operation and Maintenance Manual:
 - (a) Provide complete parts, operating, and maintenance manual covering equipment at time of installation including, but not limited to:
 - i. Description of system and components.
 - ii. Schematic diagrams of electrical, plumbing, and drainage systems.
 - iii. Manufacturer's printed operating and maintenance instructions.
 - iv. List of original manufacturer's parts, including suppliers' part numbers and cuts, recommended spare parts, stock quantity, and local parts and

service source.

- (b) Assemble and provide four (4) copies of manual, per location, in 8-1/2 by 11 inch format. Foldout diagrams and illustrations are acceptable.
- (c) Provide electronic files for manual using MSWord 2007 for text and Auto CAD Latest Version /Group 4 (TIFF) Format for Drawings and Diagrams.

1.04 PRODUCT DELIVERY, STORAGE, AND HANDLING:

- A. Deliver equipment in manufacturer's containers, appropriately packaged and/or crated for protection during shipment and storage.

1.05 OPERATION AND MAINTENANCE TRAINING:

- A. Upon completion of the equipment installation and ten days before start-up, a qualified representative of the manufacturer shall be present for a minimum of three (3), eight (8) hour working days to instruct personnel in the operation and proper care of the equipment at each location.
 - 1. Instructional period: Three consecutive man-days minimum. A minimum of one day to be devoted to hands-on demonstration of the equipment operation, trouble analysis, repair, adjustment and maintenance.
 - 2. Train personnel in preventive maintenance of systems and to recognize malfunctions.
 - 3. Provide complete printed operating instructions in manual or handbook form, completely and clearly indexed for ready reference during actual operation and for use as text during instruction of operating personnel.
 - (a) Include descriptions of systems, background information and complete procedures for adjustment, calibration, replacement and repair of components in the system(s).

1.06 LABELING:

- A. Manufacturer shall securely attach in a prominent location on each major item of equipment a non-corrosive nameplate showing manufacturer's name, address, model number, serial number, and pertinent utility or operating data.
- B. Label all added/modified piping as to its function and flow direction.
- C. Label all new/modified circuits in power panels.

PART 2. PRODUCTS

2.01 MAJOR EQUIPMENT SELECTION

- A. All water-cooled chillers shall be selected and installed as specified in Section 15625A.
- B. Chilled water and condenser water pumps shall be selected and installed as specified in Section 15185.
- C. All refrigerant monitoring and safety equipment shall be selected and installed as specified in Section 15635.

2.02 MISCELLANEOUS

- A. All facilities restoration work shall be performed as specified in Section 02205.
- B. All demolition work shall be performed as specified in Section 02225.
- C. All structural work shall be performed as specified in Section 05120.
- D. All field painting shall be performed as specified in Section 09920.
- E. HVAC motors and variable frequency drives shall be selected and installed as specified in Section 15055.
- F. All mechanical equipment and piping shall have vibration isolation as specified in Section 15070.
- G. All mechanical equipment and piping shall be identified as specified in Section 15075.
- H. All equipment and piping insulation shall be selected and installed as specified in Section 15080.
- I. Water treatment system shall be selected and installed as specified in Section 15186.
- J. All piping shall be selected, installed and tested as specified in Section 15205.
- K. Chiller plant monitoring shall be selected and installed as specified in Section 15900.
- L. All systems shall be tested and balanced in accordance with Section 15950.
- M. All wiring and equipment shall comply with grounding and bonding requirements as specified in Section 16060.
- N. All wire and cable shall be selected, installed, and tested as specified in Section 16120.
- O. All raceways, boxes and cabinets shall be selected, installed and tested as specified in Section 16130.
- P. All motors shall be selected, installed and tested as specified in Section 15055 except as noted above. All motor enclosures shall be rated "water-proof".
- Q. All motor starters and control center components shall be installed and tested as specified in Section 16425.
- R. All circuit breakers, panel boards, and load centers shall be selected, installed and tested as specified in Section 16440 except as noted above.

PART 3. EXECUTION

3.01 SITE PREPARATION

- A. Provide scoping and design documentation (drawings) for construction of required equipment supports and other mounts not originally specified in this document.
- B. Coordinate the installation of equipment supports with the demolition and reconstruction work of the HVAC, plumbing, and electrical contractors.

3.02 INSPECTION

- A. Check location of rough-in work and utility stub-outs to assure match with the equipment to be installed.
- B. Inspect delivered equipment for damage from shipping and exposure to weather. Compare delivered equipment with packing lists and specifications to assure receipt of all items.
- C. Report in writing to the AR any damaged, missing or incomplete scheduled equipment and improper rough-in work or utility stub-outs.

3.03 INSTALLATION

- A. The Contractor shall be responsible for complete operational equipment installation.
- B. Work shall be performed under the direct supervision of Construction Superintendent. He shall coordinate the installation of scheduled equipment with the authorized representative (AR).

C. Install equipment in accordance with plans, shop drawings and manufacturer's instructions:

1. Positioning: Place equipment in accordance with any noted special positioning requirements generally level (or slight slope as required by instructions), plumb and at right angles to adjacent work.
2. Fitting: Where field cutting or trimming is necessary, perform in a neat, accurate, professional manner without damaging equipment or adjacent work.
3. Anchorage: Use fastenings as specified herein. Attach equipment securely to prevent damage resulting from inadequate fastenings. Installation fasteners shall be installed to avoid scratching or damaging adjacent surfaces.
4. Upon completion of work, finish surfaces shall be free of tool marks, scratches, blemishes, and stains.

3.04 TESTING

- A. Specification Compliance: After final connections are made and prior to authorizing payment, specified equipment and systems shall be satisfactorily tested for compliance with all specified features.
- B. Malfunctions during testing shall be corrected within five days and retested. Malfunctions during second testing shall be corrected within five days and retested.
- C. Inadequate Performance: If equipment fails the third test, the Authority may elect to have all equipment installed by this contract removed from site at no cost or obligation to the Authority.

3.05 CLEANUP

- A. Touch-up damage to painted finishes.
- B. Wipe and clean equipment of any oil, grease, and solvents, and make ready for use.
- C. Clean area around equipment installation and remove packing or installation debris from job site.
- D. Notify AR for scheduling of acceptance inspections.

3.06 WARRANTY

- A. In addition to the requirements of the General Provisions, the equipment shall be guaranteed against defective parts and faulty workmanship for a period of two (2) years after substantial completion inspection (SCI). This requirement is for all new equipment installation excluding all Chillers.
- B. Chillers: Provide five (5) year parts, labor and refrigerant warranty and preventive maintenance services for the new chillers during the warranty period.

3.07 PERSONNEL

The Contractor will perform all services using factory-trained technicians who have required Federal and jurisdictional certifications and specialize in HVAC, refrigeration and electronic system maintenance and repair service.

3.08 REPAIR SERVICE

The Contractor will perform all services during its regular working hours unless otherwise specified. Any services requested or agreed to by the Authority that are outside the Scope of Work will be performed by the Contractor as a contract modification.

3.09 REPORTS

The Contractor will provide the AR with a detailed report of the services performed on each inspection. Report shall be submitted to AR, shall include equipment log readings taken during inspection, condition of equipment, recommended repairs and/or services performed.

3.10 ADDITIONAL SERVICES

Additional services will be furnished upon request and proper authorization from the Authority. All additional services will be requested in writing according to contract modification procedures.

3.11 EMERGENCY SERVICE

Emergency service will be available, for the chillers under the five year warranty only, on a 7 day, 24-hour basis at no additional cost.

3.12 SCOPE OF SERVICE

- A. Contractor will perform the following services pursuant to the terms of this contract:
 - 1. Perform five monthly inspections and one annual shutdown service on the equipment listed between May 15 and October 15.
 - 2. Complete seasonal start-up services as described below once per year prior to May 15.
- B. In addition, the following service applies to the air conditioning equipment listed as water cooled chillers:
 - 1. Parts and Labor Coverage - furnish all labor, parts, and supplies necessary to make repairs, adjustments and routine maintenance.
 - 2. Miscellaneous Parts Coverage - provide coverage for miscellaneous replacement of relays, controls, for control panels.
 - 3. Provide MOD-BUS communication service for the duration of the Agreement.
- C. **Contractor Maintenance Service shall include:**
 - 1. Furnish all labor, parts, refrigerant, oil, and material needed to maintain the equipment in good operating condition. Perform service during normal working hours, unless otherwise specified herein, and the maintenance service shall be in accordance with the scope previously stated. Annually brush clean the water side of water cooled condensers with procedures determined by the equipment manufacturer.
 - 2. Maintain the following items related to the Equipment:
 - (a) Electric wiring from the starter to its respective motor on unit mounted starters only.
 - (b) Refrigerant piping between two or more pieces of Equipment, if installed per manufacturer's recommendations.
 - (c) Insulation on the refrigerant piping and Equipment if disturbed to perform service.
 - (d) The pressure and temperature controls, thermometers, gauges, control devices, thermostats and manual valves located on the Equipment.

- (e) Starters. (Excludes line side damage.)
- 3. Provide a written report to the Authority about the condition of the Equipment and any recommendations for enhancements to maintain capacity, reliability, and efficiency.
- 4. The following tasks are performed during the annual inspection once each year during a shutdown period in order to properly evaluate equipment status and prepare unit for the next cooling season:
 - (a) Test for refrigerant leaks including relief valve piping outlets.
 - (b) Check main starter, control panel, and frequency drives.
 - (c) Inspect and tighten electrical connections.
 - (d) Check relays, operating, and safety controls.
 - (e) Check flow switch operation.
 - (f) Measure and record water side pressure drops across vessels.
 - (g) Perform equipment monitoring system check, log, and last fault analyses. Analyze performance, trend log if necessary.
 - (h) Download latest software version if applicable.
 - (i) Check compressor readouts.
 - (j) Inspect vibration eliminators and inspect water piping for leaks.
 - (k) Check head pressure control operation for tower fans or bypass valve.
 - (l) Check minimum condenser water temperature operation.
 - (m) Manually clean water side of condenser. (Removal of one head only.)
 - (n) Head removal by Contractor.
- 5. The following tasks are performed during seasonal startups:
 - (a) Review manufacturer's recommendations for startup.
 - (b) Check auxiliary equipment operation.
 - (c) Download latest software version if applicable.
 - (d) Check relays, operating, and safety controls.
 - (e) Start chilled water pump(s).
 - (f) Start condenser water pump(s) and cooling tower.
 - (g) Start water chiller.
- 6. The following tasks shall be performed during monthly maintenance inspections:
 - (a) Log all operating conditions after unit stabilizes.
 - (b) Review operating procedures with chiller operator.
 - (c) Review owner's log for trends.
 - (d) Inspect chiller for leaks.
 - (e) Inspect starter for burns and discoloration.
 - (f) Run chiller and log readings, analyze performance.
 - (g) Record unusual noises and vibrations.
 - (h) Record refrigerant level in sight glass.
 - (i) Review chiller operation with chiller operator.
 - (j) Test for refrigerant leaks including relief valve piping outlets.
 - (k) Check main starter and control panel.
 - (l) Check relays, operating, and safety controls.
 - (m) Check flow switch operation.
 - (n) Perform equipment monitoring system check, log, and last fault analysis, analyze performance.

D. Authority agrees to:

1. Designate a representative in its employ to receive instructions in the operation of the equipment. Such representative shall have authority to carry out recommendations received from manufacturer in conjunction with the performance of this Agreement.
2. Allow Contractor to start and stop the Equipment in order to perform services specified in this Agreement.
3. Operate the Equipment in accordance with manufacturer's instruction, and to notify Contractor promptly of any change in the usual operating conditions.
4. Provide reasonable means of access to the Equipment, including any required removal, replacement and refinishing of the building structure.
5. Permit the use by Contractor of the usual building maintenance materials and tools.
6. Employ only Contractor personnel or persons authorized by Contractor to perform all work on the Equipment, except for operation of same.
7. Provide proper condenser water treatment.

END OF SECTION

SECTION 02205

REMOVAL AND RESTORATION OF EXISTING FACILITIES

PART 1 GENERAL

1.01 DESCRIPTION:

- A. This section specifies removing, restoring, and reinstalling miscellaneous items on WMATA property which are removed during construction.
- B. Related Work Specified Elsewhere:
 - 1. Selective Demolition: Section 02225.
- C. Definitions:
 - 1. Miscellaneous items include, but are not limited to, the following: finishes, walls, partitions, doors, door frames, plumbing fixtures, mechanical items, lighting, operators, controls, and other utility facilities indicated on the Contract Drawings and located in areas to be cleared.
 - 2. Salvage: To remove and store material and equipment for reuse indicated on the Contract Drawings and located in areas to be cleared in this or other Authority contracts.
- D. Salvage:
 - 1. Items to be salvaged as indicated on the Contract Drawings.
 - 2. Clean salvaged items of foreign material and store in accordance with the General Requirements unless otherwise shown, approved or directed.
 - 3. Unless otherwise specified, items removed but not to be salvaged will become the property of the Contractor.

1.2 SUBMITTALS (NOT USED):

1.3 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
 - 1. Comply with codes and regulations of the jurisdictional authorities.

PART 2 PRODUCTS

(NOT USED)

PART 3 EXECUTION

3.1 REMOVALS:

- A. Remove work to extent shown avoid damage to work which is to remain in place. Do not remove structural items without prior written approval of AR.

3.2 STORE FRONTS, BAY WINDOWS AND CORNICES (NOT USED):

3.3 ALARM AND SPRINKLER SYSTEMS AND FIRE ESCAPES (NOT USED):

3.4 CANOPIES, AWNINGS AND GRILLES (NOT USED):

3.5 VAULTS (NOT USED):

3.6 HEATING, COOLING AND ELECTRICAL FACILITIES (NOT USED):

3.7 SIGNS, FLAGPOLES, RAILINGS AND FENCES:

A. Signs:

1. All signs must comply with WMATA standards.

3.8 FLOORS, CEILINGS, WALLS, PARTITIONS AND OTHER FINISHES:

- A. Where cutting and patching of floors, ceilings, walls, partitions and other exposed work is necessary, provide such items in accordance with the Technical Sections of this document so as to maintain continuity of quality and appearance between existing and new construction.

3.9 SIDEWALKS AND CURBS (NOT USED):

3.10 PARKING AREAS AND DRIVEWAY PAVEMENTS (NOT USED):

3.11 LANDSCAPING (NOT USED):

3.12 JOINTS BETWEEN EXISTING AND RESTORED WORK:

- A. Make joints between existing and restored work as inconspicuous as practicable.
- B. Use saw to cut straight line at joint between existing and new concrete, steel and masonry surfaces.
- C. Make joints between existing and restored work at least equal structurally to original undisturbed items.

* * *

END OF SECTION

SECTION 02225

SELECTIVE DEMOLITION

PART 1 GENERAL

1.1 DESCRIPTION:

- A. This section specifies selective demolition work.
- B. Related Work Specified Elsewhere:
 - 1. Removal and restoration of miscellaneous facilities: Section 02205.
- C. Definitions:
 - 1. Selective Demolition: Complete removal and disposal of existing materials, systems and components from areas indicated in the Contract Documents and located in areas to be cleared.
 - 2. Existing materials, systems and components include, but are not restricted to, finishes, walls, partitions, doors, door frames, plumbing fixtures, mechanical items, lighting, operators, controls, and other utility facilities indicated on the Contract Drawings and located in areas to be cleared.
 - 3. Salvage: To remove and store material and equipment for reuse indicated on the Contract Drawings and located in areas to be cleared in this or other Authority contracts.

1.2 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Certification:
 - 1. Submit copy of request to utility companies owning or agency controlling services and appurtenances affected by selective demolition work for discontinuance of services along with certificates of severance.
- B. Documentation:
 - 1. Demolition permit from the jurisdictional agency and Authority Representative.
 - 2. Permits and releases from each owner of property where demolition debris will be deposited absolving the Authority of responsibility in connection with such disposal.
- C. Schedule and concise narrative of selective demolition activities indicating the following:
 - 1. Detailed sequence of selective demolition and removal work, with starting and ending dates for each activity.
 - 2. Interruption of utility services.
 - 3. Coordination for shutoff, capping, and continuation of utility services.
 - 4. Requested use of stairs. Use of building elevators, restrooms and stairs by personnel associated with this project will be prohibited.
 - 5. Detailed sequence of selective demolition and removal work to ensure protection of existing components and systems that are to remain as well as components, systems, workers, occupants and the public at, below and/or adjacent to the work area. Address all specific fire watch and safety

- technics that shall be required to perform each activity.
- 6. Coordination of WMATA's continuing occupancy of portions of existing building and of WMATA's partial occupancy of completed work.
- 7. Locations of temporary partitions and means of egress.
- 8. Coordinate the location of equipment to remove existing material and stage delivery and storage of new roof materials required with WMATA.

- D. Demolition Firm Qualifications
- E. Certification of compliance with regulatory requirements
- F. Agenda and list of attendees for the Pre-demolition Conference

1.3 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:

- 1. Comply with codes and regulations of the jurisdictional authorities.

- B. Demolition Firm Qualifications: Engage an experienced firm that can demonstrate a minimum of 5 years of successful completion of selective demolition work similar to that indicated for this Project.
- C. Pre-demolition Conference: Conduct conference at Project site prior to demolition.
- D. Approved safety permits and technicians shall be required to perform each activity.
- E. Approved fire watch permits and technicians shall be required to perform each activity involving cutting, welding torching and/or any other burning activity as well as during any activity involving the use of volatile and/or combustible material as identified in the required MSDS. A fire watch shall monitor above, below, adjacent and at the component being monitored and shall remain in effect until temperature of all the affected components is equal to or less than 120 degrees F.

1.4 JOB CONDITIONS:

A. Metrorail Ancillary Booths:

- 1. Selectively remove work to extend shown avoiding damage to materials, systems and components to accommodate the new work in areas indicated in the Contract Documents and located in areas to be cleared. Repair or replace to match existing any damaged items, materials, systems and components not indicated for removal.

- B. WMATA occupies portions of the infrastructure immediately adjacent and/or below the selective demolition area. Conduct selective demolition so that safety will not be compromised. Provide not less than 72 hours' notice to the AR of activities that will affect WMATA's operations and/or WMATA and the public's safety.

C. Street and Road Closures:

- 1. Make arrangements with appropriate jurisdictional agency for temporary closing of public streets or highways to traffic as necessary.
- 2. Arrange with the appropriate agency for the rerouting of traffic and comply with its regulations.
- 3. Furnish and maintain temporary signs, barricades, flashing lights and flag persons necessitated by the work and remove same upon completion of work.

D. Maintenance of Traffic:

- 1. Construct, maintain and remove on completion of work, temporary canopies and other structures for protection of the public in accordance with applicable codes to ensure continuous safety of traffic.
- 2. Bridge cuts in traffic areas with steel plates or by other approved means.

3. Keep traffic areas free from debris and spillage of materials.
4. When demolition work interferes with bus loading facilities, provide and maintain surfaced areas at alternative locations or arrange rerouting with appropriate authorities for duration of work.

E. Protection and Restoration:

1. Prevent damage to walls, equipment, pipes, conduits, wires, cables and structures above and below ground which are not indicated for removal. Repair or replace to match existing any damaged items, materials, systems and components not indicated for removal. All materials, systems and components which are not indicated for removal shall be protected.

1.5 SCHEDULING:

- A. Arrange selective demolition schedule so as not to interfere with WMATA's on-site operations.
- B. Coordinate with Authority Representative on any interior operation that may be interrupted.
- C. Contractor shall provide measures to protect the public, equipment and systems during the removal .

PART 2 - PRODUCTS

- A. Provide temporary protection, barriers and other environmental and safety devices complying with WMATA's safety requirements, all jurisdictional codes, regulations, safety requirements, reference standards and specifications as well as other jurisdictional agencies' requirements pertaining to this project.
- B. Provide necessary equipment and material required to perform the work.

PART 3 EXECUTION

3.1 EXAMINATION:

- A. Verify that utilities, as required, have been disconnected and capped at wye or tee.
- B. Survey existing conditions and correlate with requirements indicated to determine extent of selective demolition required.
- C. Inventory and record the condition of items to be removed and reinstalled and items to be removed and salvaged.
- D. Survey the condition to determine whether removing any element might result in structural deficiency or unplanned collapse of any portion of the structure or adjacent structures during selective demolition.
- E. Perform surveys as the Work progresses to detect hazards resulting from selective demolition activities.

3.2 UTILITY SERVICES:

- A. Do not interrupt existing utilities serving occupied or operating facilities, except when authorized in writing by the AR and authorities having jurisdiction. Provide temporary services during interruptions to existing utilities, as acceptable to the AR and to governing authorities.
 1. Provide not less than 5 workdays' notice to AR if shutdown of service is required.

3.3 PREPARATION:

- A. Conduct demolition operations and remove debris to ensure minimum interference with roads, streets, walks, corridors, work areas and other adjacent occupied and used facilities:
 - 1. Preparation & pollution controls should be installed prior to demolition so HVAC can be isolated from occupied areas.
 - 2. Do not close or obstruct streets, walks, corridors, or other adjacent occupied or used facilities without permission from the AR and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by governing regulations.
- B. Conduct demolition operations to prevent injury to people and damage to adjacent buildings and facilities to remain. Ensure safe passage of people around selective demolition area.
 - 1. Erect temporary protection, such as walks, fences, railings, canopies, and covered passageways, were required by authorities having jurisdiction.
 - 2. Protect existing site improvements and appurtenances to remain.
 - 3. Ensure that no water leakage or damage occurs to structure or interior areas.
 - 4. Protect walls, ceilings, floors, and other existing finish work that are to remain and are exposed during selective demolition operations.

3.4 POLLUTION CONTROLS:

- A. Use temporary enclosures, and other suitable methods to limit the spread of dust and dirt. Comply with governing environmental protection regulations:
 - 1. Do not use water when it may damage existing construction or create hazardous or objectionable conditions, such as ice, flooding, and pollution.
- B. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas:
 - 1. Remove debris from elevated portions by chute or other device that will convey debris to grade level.
- C. Clean adjacent structures and improvements of dust, dirt, and debris caused by selective demolition operations. Return adjacent areas to condition existing before start of selective demolition.

3.5 SELECTIVE DEMOLITION:

- A. Demolish and remove existing, knock-out walls, concrete walls, and structural elements as indicated on plans. Do not abandon and cap sewer and drain lines. Also piping to be removed should not be abandoned or crimped. Use methods required to complete Work within limitations of governing regulations and as follows:
 - 1. Proceed with selective demolition systematically, from higher to lower level.
 - 2. Remove decayed, vermin-infested, or otherwise dangerous or unsuitable materials and promptly dispose of off-site.
 - 3. Dispose of demolished items and materials promptly. On-site storage or sale of removed items is prohibited.
 - 4. Return elements of construction and surfaces to remain to condition existing before start of selective demolition operations.

- B. Remove and replace, as required, air handling units, and associated appurtenances.

3.6 ISOLATED PATCHING AND REPAIRS:

- A. Promptly patch and repair damaged surfaces caused to adjacent construction by selective demolition operations.
- B. Where repairs to existing surfaces are required, patch to produce surfaces suitable for new materials.
 - 1. Completely fill holes and depressions in existing masonry walls to remain with an approved masonry patching material, applied according to manufacturer's printed recommendations.
- C. Restore exposed finishes of patched areas and extend finish restoration into adjoining construction to remain in a manner that eliminates evidence of patching and refinishing.

3.7 GENERAL REPAIRS

- A. If upon removal of an existing system exposes widespread deterioration, the contractor shall promptly notify the AR.
- B. The contractor shall provide to the AR for approval, a schedule that will integrate selective demolition work and new installation. The contractor's schedule shall measure the overall impact that such selective demolition work will have on the general period of construction. Any revisions to the overall project contract duration must be approved by the AR.
- C. See Paragraph 3.8 "Disposal of Demolished Materials" below for coordination of existing equipment and appurtenances to remain.

3.8 DISPOSAL OF DEMOLISHED MATERIALS:

- A. General: Promptly dispose of demolished materials to locations outside Authority's right-of-way. Do not allow demolished materials to accumulate on-site.
- B. Dispose of debris off site only with permission of property owner where such debris is to be deposited and in accordance with codes and regulations of the jurisdictional authorities.
- C. Burning: Do not burn demolished materials.

* * *

END OF SECTION

SECTION 03900

MINOR REPAIRS TO EXISTING CONCRETE

PART 1 GENERAL

1.1 DESCRIPTION:

- A. This section specifies providing Portland cement cast-in-place concrete to provide minor repairs and infill to existing concrete.

1.2 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
 - 1. Comply with codes and regulations of the jurisdictional authorities.
 - 2. ACI: 201.2R, 211.1, 304, 309, 318, 318.1.
 - 3. AASHTO: M182, T26.
 - 4. NBS: Handbook 44.
 - 5. USBR: Concrete Manual.
 - 6. FS: A-A-341A, HH-I-521, K-P-146.
 - 7. ASTM: A43, A47, A48, C31, C33, C39, C40, C42, C87, C88, C94, C131, C150, C171, C172, C260, C295, C309, C311, C330, C494, C535, C586, C595, C618, C665, C685, C881, C989, C1107, C1260, D98, E328.
 - 8. CPMB (Concrete Plant Manufacturer's Bureau): Concrete Plant Standards.
- B. Properties of Concrete:
 - 1. General:
 - a) Design mixes to produce concrete of proper workability, durability, strength, maximum density, minimum shrinkage and permeability.
 - b) Design mixes to have minimum water content per cubic yard of concrete, cement content corresponding to appropriate water-cement ratio, largest permissible maximum size specified of coarse aggregate available and optimum percentage of fine aggregate.
 - c) Use maximum size of coarse aggregate in accordance with ACI 211.1.
 - d) Use same brand from same source throughout the work.
 - e) Use aggregates from same source throughout the work.
 - f) Use ground-iron blast-furnace slag and fly ash from the same sources respectively throughout the work.
 - 2. Durability:
 - a) Maximum water cementitious materials ratio as per ACI 318, Chapter 4 and ACI 201.2R.
 - b) Use a suitable combination of approved air-entraining admixture and water reducer to reduce water content and permeability of the concrete, provided such admixtures do not adversely affect other specified properties of concrete.
 - 3. Workability:

- a) Use approved chemical admixtures as needed for workability so that concrete can be placed, consolidated, and finished without segregation or excessive bleeding.

4. Strength:

- a) Design mix for each class and type of concrete of each specified strength based on overdesign factor in accordance with ASTM C94. Unless otherwise shown, working-stress method applies to structures.

- b) Design each class of concrete in accordance with the following:

- (1) Not more than the following percentages of strength tests to have values less than specified strength:

- (a) Working-stress method: 20 percent.
- (b) Ultimate-strength method: 10 percent.
- (c) Pre-stressed structures: 10 percent.

- (2) Average of the following numbers of consecutive strength tests to be equal to or greater than specified strength:

- (a) Working-stress method: Six.
- (b) Ultimate-strength method: Three.
- (c) Pre-stressed structures: Three.

When number of tests totals six or less, average to be in accordance with Note 21 of ASTM C94.

5. Appearance:

- a) Cured concrete within public view to be uniform in color, texture and finish with no objectionable form marks or irregularities in joints.

C. Method of Proportioning:

- 1. Proportion mixes as described in ACI 211.1.
- 2. Approximate mixing-water and air-content requirements for mixes of different slumps and nominal maximum sizes of aggregates as specified in ACI 211.1, Table 5.3.3.
- 3. Do not vary proportions of ingredients of approved mixes without written approval.

D. Ready-Mixed Concrete: ASTM C94.

1.3 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Product Data:** Manufacturer's literature completely describing each material, standard, test data, installation instructions and special instructions or safety precautions applicable to the materials.

- B. Certification:**

- 1. Ingredients:

- a) Submit with mix design, laboratory test reports and mill or manufacturer's certificates verifying that ingredients conform to specified requirements. Use

ingredients in design mix which are representative samples of materials to be used in the work.

- (1) Submit test results whenever the aggregates, cement or other additives to be used in the concrete come from a different lot, source, other area of the quarry, different quarry or from other than the representative stockpile or batch from which the original material was tested and approved.
- b) In case the source, brand or characteristic properties of ingredients need to be varied during the term of the Contract, submit revised laboratory-mix report in accordance with procedures specified for original mix design.

1.4 WARRANTY:

- A. Penetrating Concrete Sealer: Provide a minimum effective service life warranty of 10 years for the penetrating concrete sealer.
- B. Penetrating Concrete Sealer:
 1. Penetrating silane sealer, which is readily absorbed into concrete substrate and which reacts chemically to provide a hydrophobic barrier that will not wear off when exposed to sunlight or wheel traffic; which allows concrete to breath, allowing the escape of water vapor but preventing the absorption of surface water; colorless; not altering the surface texture of the concrete substrate. See Warranty requirements.
 2. Provide one of the following:
 - a) Chem-Trete BSM 40, Hüls America, Inc. (1-800-828-0919).
 - b) Penetrating 40, Sonneborn Division Chemrex (1-800-CHEMREX).
 - c) Master Seal SL40, Master Builders Technologies.
- C. Curing Materials:
 1. Plastic sheeting: Polyethylene, ASTM C171.
 - a) Curing sheet: Type 1.1.1 and 1.1.2.
 - b) Vapor barrier: Clear 10-mils thickness.
 2. Burlap sheet: AASHTO M182, Class 3 or 4.
 3. Tarpaulin: FS K-P-146.
 4. Blanket insulation: FS HH-I-521.
 5. Membrane-forming curing compound: ASTM C309, Type 1-D, 100 resin with fugitive dye, and Type 2. D. Epoxy Mortar:
 1. Epoxy: ASTM C881, Type III-C, grey.

2. Sand: Clean, dry, well-graded particles, passing Size 16 sieve, with the following additional requirements:

<u>Individual Sieve Size</u>	<u>Percent by Weight Retained on Sieve</u>
30	26 to 36
50	18 to 28
100	11 to 21
Pan	25 to 35 (range shown is applicable when 60 to 100 percent of pan is retained on Size 200 sieve)

E. Elastomeric Concrete:

1. Elastomeric Concrete to consist of an aggregate and binder mixture proportioned by the manufacturer.
2. Manufacturer qualifications: Manufacturer to have the following minimum qualifications:
 - a) Ten years experience in the manufacturing of elastomeric concrete materials.
 - b) Qualified personnel, factory trained and certified in the proper installation procedures, are to be available during construction.
3. Manufacturers: The naming of certain manufacturers is intended to establish a standard of quality. Elastomeric Concrete from the following manufacturers is acceptable:
 - a) Delcrete Elastomeric Concrete by the DS Brown Company, PO Box 158, North Baltimore, OH 45872, telephone (419)257-3561.
 - b) Wabocrete by Watson Bowman Acme Corporation, 95 Pineview Drive, product as equal to this specification submit product information and a working sample along with independent physical test property verification, and product literature for review and approval.

F. Chairs for Reinforcement: Plastic or stainless steel.

2.2 GROUT MIXES:

A. Portland-cement grout:

1. Prepare grout composed of portland cement, sand and water.

2. Use portland-cement grout under bearing plates, in recesses, holes and surfaces under structural members and at other locations shown.
 3. Do not use staining ingredients in grout exposed to view.
 4. Formulation: Two parts sand and one-part cement measured by volume.
 5. Mix grout with sufficient water to permit placing and packing, approximately 45 minutes prior to use.
- B. Nonshrink grout: ASTM 1107.
- C. Shrinkage-compensating grout:
1. Use shrinkage-compensating grout for setting structural members, anchor bolts, embedded items or items of equipment and machinery on hardened concrete.
 2. Prepare nonstaining shrinkage-compensating grout with portland cement, sand and aluminum powder and use in accordance with manufacturer's recommendations.
 3. Prepare shrinkage-compensating grout for use up to two inches thick as follows, measured by volume:
 - a) One-part portland cement, Type I or II.
 - b) One-part fine natural-sand aggregate, graded as specified.
 - c) One-part ferrous aggregate, graded as specified, combined with Type-A chemical admixture, oxidation agent and water in sufficient amount to permit placing and packing.
- D. Premixed shrinkage-compensating grout:
1. In lieu of specified shrinkage-compensating grout, use premixed ready-to-use formulation when approved. Approval will be based on manufacturer's certification that:
 - a) Material will perform as specified.
 - b) Composition and proportioning of grout materials is essentially as specified for shrinkage-compensating.
 - c) Formulation has been used successfully in like applications for

at least five years.

2. Proportion ingredients in accordance with the manufacturer's recommendations.

E. Mixing water:

1. Proportion mixing water in accordance with grout manufacturer's recommendation or to produce flowable mixture without segregation or bleeding.

F. Curing:

1. After grout has attained initial set, keep damp for 24 hours minimum.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL:

A. Classes of Concrete:

1. Classes of concrete are designated by numerals corresponding to their specified 28-day compressive strength in pounds per square inch as determined by ASTM C94.
2. Concrete classes used in this project are Class 3500.
3. Each class of concrete may comprise one or more mixtures determined by maximum size of aggregate, cement factor and types of admixtures used.
 - a) Portland cement may be used alone or mixed with either ground-iron blast-furnace slag or fly ash. Do not use fly ash in architectural concrete exposed to public view.

B. Types of Concrete:

1. Types of concrete are designated as Concrete Other than Lightweight and Lightweight Structural Concrete.

C. Minimum Cement Factor:

1. Observe minimum cement factor for various classes of concrete other than lightweight, as follows:

Class of Concrete	Minimum Cement Factor Bags Per Cubic Yard Of Concrete
5,000	6.5
3,500 - 4,000	6.0
2,500 - 3,000	5.0

2. If a mix of portland cement and ground-iron blast-furnace slag or portland cement and fly ash is used, the mix is the basis of determining the bags per cubic yard of concrete.

D. Air Entrainment:

1. Determine air content of concrete in accordance with ASTM C94.

3.2 MATERIAL PREPARATION:

A. Mixing Concrete:

1. Operations:

- a) Provide concrete mixers that discharge concrete of uniform composition and consistency.
- b) Combine coarse aggregates of different gradation and identical sources, provided corresponding concrete mix has been approved. The use of alternate batches of gravel, crushed gravel or crushed stone of a single size is prohibited.
- c) Add water prior to, during and following mixer-charging operations. Do not overmix or add water to maintain consistency.

2. Central-mixed concrete:

- a) Arrange mixers in centralized mixing plant so that mixing action in mixers can be conveniently observed by the Authority Representative.
- b) Do not load mixers in excess of rated capacity. Mix concrete ingredients in batch mixer for not less than period of time specified for various mixer capacities after each ingredient except full amount of water is in mixer. Reduce mixing time if thorough mixing as specified can be obtained in less time and if approved.
- c) Mixing time:

Cubic-Yard Capacity of Mixer	Mixing Time
---------------------------------	----------------

2 or less	1-1/2 minutes
3	2 minutes
4	2-1/2 minutes
More than 4	To be determined per ASTM C94 tests by the Engineer

- d) Equip each mixer with mechanically operated batch counter and timing and signaling device to indicate completion of mixing period.

3. Temperature control:

- a) Use preparation methods capable of producing concrete with temperature 85F maximum and 55F minimum at time of placement.
- b) Do not heat concrete ingredients to temperature higher than that necessary to keep temperature of mixed concrete as placed within specified temperatures.

- c) Do not heat water in excess of 140F.

B. Admixtures:

1. Introduce admixtures in solution form.

2. Air-entraining admixture: Use for concrete exposed to weathering or in contact with rock or moist soil.

3. Chemical admixtures:

- a) Use water-reducing admixtures in concrete areas below grade in contact with rock, earth or fill.
- b) Employ admixtures without interfering with specified air-content dosage of air- entrained concrete.
- c) Except as otherwise specified or approved, use of water-reducing, set-

retarding or set-accelerating admixtures is prohibited.

- d) If introduction of certain admixtures to improve concrete strength is approved, do not reduce cement content below minimum amounts specified.

C. Consistency:

- 1. For concrete to be compacted by approved mechanical vibrators, maintain slump range at point of delivery within the following limits:
 - a) Concrete pavement, pavement base, sidewalk and incidental construction: Two to three inches.
 - b) Unreinforced concrete other than pavements: One to three inches.
 - c) Reinforced concrete: Two to four inches.
 - d) Concrete placed by pumping and concrete for filling steel-shell piles: Four to five inches.
 - e) Do not use concrete if slump exceeds maximum by $\frac{1}{2}$ inch or more.

D. Lightweight Structural Concrete:

- 1. Prepare lightweight structural concrete with minimum cement content as follows:

Compressive Strength	Cement Content Bags Per Cubic Yard
3,000 psi	5 to 8

- 2. Air-entrainment:
 - a) Use air-entraining admixture in lightweight structural concrete to provide not less than four not more than six percent of entrained air.
- 3. Dry unit weight:

- a) Prepare lightweight structural concrete to provide air-dry weight required by design but not less than 90 pounds per cubic foot.
- 4. Consistency:
 - a) Maintain slump range within two to four inches.

3.3 CONVEYING:

- A. General:
 - 1. Provide equipment for conveying concrete from mixer with continuous flow of concrete to point of placement without segregation.
 - 2. Provide arrangement at discharge end of conveyor to prevent segregation.
- B. Chutes and Troughs:
 - 1. Use only ferrous-metal-lined chutes and open troughs. Where steep slopes are unavoidable, equip chutes or troughs with baffles to minimize segregation of aggregates. Keep chutes or open troughs clean of hardened concrete by flushing with water after each use.
 - 2. Discharge water used for cleaning outside lines of structure. Lay out chutes or open troughs with slope one-foot vertical to two feet horizontal maximum and one-foot vertical to three feet horizontal minimum.
 - 3. Discharge chutes 20 feet or more in length into hopper before final distribution.
- C. Adjustable Length Pipes (Elephant Trunks):
 - 1. Use flexible pipes of ferrous metal, rubber or plastic, six inches minimum diameter so as to prevent segregation of concrete.
 - 2. Position chutes or flexible pipes so that concrete is delivered in continuous flow to points not more than five feet horizontally and five feet vertically from final location. In vicinity of expansion and contraction joints, reduce horizontal distance to three feet maximum.
 - 3. Clean flexible pipes and elephant trunks after each use.
- D. Buggies:
 - 1. Construct runways for buggies so they will not come into contact with or be supported by Reinforcing steel of structure.
- E. Pumping and Pneumatic Conveying Equipment:
 - 1. Use pumping and pneumatic conveying equipment, designed to handle without segregation types, classes and volumes of concrete to be conveyed.
 - 2. Operate pump or pneumatic equipment so that continuous stream of concrete without air pockets is produced. Position discharge end of line as near final position of concrete as possible but in no case more than five feet away.
 - 3. At conclusion of placement, clean equipment. Discharge debris and flushing water outside of forms.

3.4 PLACEMENT:

A. General:

1. Prior to placing concrete, remove debris and extraneous material from interior of forms.
2. Place first lift of concrete on wet surface. Consolidate by dragging vibrator along edges of joints. Make sure there is no free or standing water over the surface.
3. Place concrete continuously and as rapidly as possible after mixing. Do not use vibrators for shifting mass of fresh concrete.
4. Place concrete in layers of such thickness that no concrete will be deposited on concrete which has hardened sufficiently to cause formation of seams or planes of weakness. Cover each layer of concrete with fresh concrete within 45 minutes.
5. Do not place concrete which has attained initial set or concrete which has contained mix water for more than 90 minutes.
6. Remove temporary spreaders in forms when concrete has reached elevation which makes them unnecessary.
7. Place column concrete using adjustable-length flexible pipes or elephant trunks to avoid dropping concrete over five feet. In monolithic placements, do not deposit concrete in supported elements such as beams, girders and slabs until concrete previously deposited in columns or walls has completed its settlement shrinkage, but not to the point at which concrete in supporting members will not permit vibrator to sink into its mass of its own weight.
8. Placing will not be permitted when sun, heat, wind or limitations of facilities will prevent finishing and curing.
9. Concrete temperature at time of placement:
 - a. 55F, minimum.
 - b. 85F, maximum.
10. Unless approved, do not continue concreting when descending ambient air temperature falls lower than 40F.
11. Prior to placing fresh concrete against rock or previously placed concrete, take necessary steps, such as flushing with water, to ensure

removal of foreign matter which would adversely affect bond.

12. Maintain wire fabric and other reinforcing in proper position on chairs during concrete placement.

B. Consolidation:

1. Consolidate concrete thoroughly as it is placed in order to secure a dense mass. Work concrete well around reinforcement, embedded items and into the corners of forms. Consolidate concrete in accordance with ACI 309.
2. Use internal vibrators unless external vibrators are approved.
3. Use vibrators capable of generating frequencies of not less than 7,000 impulses per minute. Verify that vibrators have power and amplitude factor so as to visibly affect mass of concrete of one-inch slump over radius of at least 18 inches. Prevent formation of laitance and accumulation of excessive water on surface of concrete as it is deposited. Remove excessive water by pumping or other approved means.
4. When consolidating concrete in haunches, girders, beams or slabs, ensure that vibrator penetrates and revibrates previously placed concrete in top of supporting members.
5. Do not use vibrators where internal vibration might cause damage to embedded items; in such cases spading is required.

3.5 CURING AND PROTECTING:

A. General:

1. Protect freshly placed concrete from excessively hot or cold temperatures. Maintain without drying for period of time necessary for hydration of cement and proper hardening of concrete.
2. Provide sufficient tarpaulins to cover completely or enclose forms and working areas prior to and during placing and finishing operations.
3. Cure newly placed concrete continuously for seven days at ambient temperature in excess of 55F.
4. Cure concrete in subway structures by normal curing method specified.
5. During curing period keep steel and wood forms wet. If forms are removed during curing, use one of the following methods of curing immediately and continue for remainder of the curing period.

B. Normal Curing and Protection:

1. Use one of the following methods for flat surfaces, weather permitting:

- a) Use ponding on horizontal surfaces providing surface is continuously submerged for required curing period.
- b) Apply continuous sprinkling with nozzle or nozzles which, during first 24 hours, atomize flow of water providing a mist and not a spray. Do not apply moisture under pressure directly upon concrete; avoid flowing or washing on surfaces while susceptible to erosion.
- c) Cover entire surface of concrete with double thickness burlap sheet, laid directly on concrete and kept continuously wet. Maintain in good condition.
- d) Sprinkle concrete surface as specified for at least 18 hours and immediately cover with waterproof curing sheet, free from holes or tears. Hold in position so that entire surface of concrete is fully and continuously covered.
- e) Do not damage burlap, waterproof sheet or concrete surfaces.

C. Membrane-Forming Curing Compound:

- 1. Use curing compound when approved for circumstances where application of moisture is impracticable and where such compounds will not jeopardize appearance of concrete. Except as otherwise specified, use Type-1 compound, uniformly applied over surface at thickness recommended by manufacturer. Thoroughly mix compound and apply within one hour after mixing.
- 2. Where surfaces are subject to sunlight, apply Type-2 compound. Except for surfaces exposed to public view and architectural finished concrete.
- 3. Do not apply wax-resin curing compounds to surfaces requiring bond for additional concrete or where bonded surface coating such as paint, tile, dampproofing, waterproofing or roofing is to be applied.
 - a) Do not apply curing compound to floors to be chemically sealed.
- 4. Warm or stir curing compound if necessary for satisfactory application in Accordance with manufacturer's recommendations. If film of compound is damaged before expiration of curing period, repair immediately with additional compound.
- 5. Inside surfaces of tunnels, cut-and-cover boxes and other surfaces specifically approved may be cured with Type-1 membrane curing compound.
- 6. Finish surfaces prior to application of curing compound. Do not use curing compound on construction joints.
- 7. Apply curing compound in two coats. Apply first coat immediately after

stripping of forms and acceptance of concrete finish.

8. If surface is dry, thoroughly wet concrete with water and apply curing compound just as surface film of water disappears. Apply second coat after first coat has set.
9. Protect coating against damage for at least 10 days after application. If damage occurs, apply additional coating.
10. If use of curing compound results in streaked or blotchy appearance, cease operations and use other method of curing until cause of defective appearance is corrected.

C. Floor Treatment:

1. In accordance with recommendations of manufacturer of floor hardener, apply floor curing compound and curing sheet to surfaces to receive floor hardener.
2. Where such surfaces are subject to sunlight, protect them by tenting white opaque, polyethylene waterproof sheet.

D. Protection of Rod Reinforcement:

1. After forms are removed, coat rod reinforcement and dowels extending beyond concrete surfaces with application of neat cement paste.
2. Remove hardened cement paste and resultant debris immediately prior to extension of reinforcement or installation of formwork.

3.6 COLD WEATHER CONCRETING:

- A. Do not place concrete when ambient temperature is less than 55 ° F and falling. Do not place concrete unless the form temperature at the time of placement is at least 40 ° F.
- B. When ambient temperature is 40 ° F and falling, carry out one of the following procedures to protect placed concrete:
 1. Heating:
 - a) Enclose forms or structures and heat to maintain concrete and air within enclosure at not less than 55 ° F for seven days after

placement.

- b) Maintain relative humidity at not less than 40 percent during curing period when heat is applied to enclosures. Arrange stoves, salamanders or heaters so as to provide uniform distribution of heat. Vent combustion gases to outside air. Do not let hot air blow across concrete surfaces.
- c) After seven-day curing period, reduce temperature within enclosure gradually at maximum rate of 20 ° F per day until outside temperature has been reached.
- d) Provide continuous and adequate fire protection and watchmen when heating units are in operation.

2. Form insulation:

- a) Insulate forms with blanket insulation of approved type and thickness to maintain concrete at 55 ° F minimum for seven days.
- b) Protect top of placed concrete by tarpaulins or other approved waterproof material over insulation.

- C. Do not allow concrete to freeze in a saturated condition prior to achieving a strength of 4000 psi.

3.7 HOT WEATHER CONCRETING:

- A. When temperature in forms is 75F or above, carry out the following procedures to protect placed concrete:
 - 1. Protect concrete from direct sunlight.
 - 2. Keep forms moist by means of cool-water sprinkling or application of wet burlap or cotton mats.
 - 3. At 90F or above cool aggregates with water spray hoses.
 - 4. Cool truck barrels with water spray system.

3.8 JOINTS:

- A. General:

1. Unless otherwise shown make construction joints bonded joints by roughening surface to expose aggregates. Clean and roughen surface by wet sandblasting, by cutting with high-pressure water jet with a minimum pressure of 2,000 psi or by other approved means. Perform cleaning after concrete has hardened to prevent raveling of surface.
2. Exercise caution in cleaning concrete to prevent damage to waterstops.
3. Treat overlays on slabs the same as for rock or other bonded joint.
4. Place construction joints at locations shown, or at locations approved by the AR.

B. Horizontal Construction Joints:

1. Joints within 18 inches of tops of faces are prohibited.
2. Trowel top surface of concrete adjacent to forms smooth to minimize visible joints on exposed faces. Remove laitance and other objectionable materials from joint surface to expose sound concrete as soon as concrete is firm enough to retain its form.
3. Immediately after placement of concrete, remove accumulations splashed on exposed reinforcement and surfaces of adjacent forms before concrete attains initial set.

C. Other Joints:

1. Place concrete for rock tunnels with vertical contraction joints, with vertical or sloping construction joints or continuously without joints.
2. Install forms for vertical joints. Remove forms as soon as concrete has attained sufficient strength to be self-supporting.

D. Waterstops:

1. Rework or replace concrete where waterstop has moved unacceptably.
2. Support water stop in exact position, do not sink water stops in fresh concrete.

3.9 CONCRETE FINISHING:

- A. When forms are removed, do not remedy voids, stone pockets and other defects until the Authority Representative has inspected them and given directions.
- B. Finish concrete surfaces as follows:
 - 1. Number-1 Form Finish:
 - a) Immediately following form removal, remove fins and irregular projections from surfaces exposed to view or those that will receive waterproofing.
 - b) Prepare pointing mortar not more than 30 minutes prior to use.
 - c) Cure mortar patches as specified under curing and protection.
 - d) Leave contraction joints and articulated joints in completed work carefully tooled and free of mortar and concrete.
 - e) Leave joint filler exposed for its full length with clean and true edges.
 - f) Apply this finish to structures, unless otherwise shown.
 - 2. Number-2 Wet-Rubbed Finish:
 - a) Start rubbing of concrete after removal of forms and as soon as its condition will permit. Keep concrete thoroughly saturated with water before starting this work.
 - b) Allow sufficient time to elapse before wetting down to allow pointing mortar to thoroughly set. Rub surfaces with medium-coarse carborundum stone.
 - c) Continue rubbing until form marks, projections and irregularities have been removed, voids are filled and uniform surface is obtained.
 - d) Leave paste produced by rubbing in place. Obtain final finish by rubbing with fine carborundum stone and water after concrete above surface being treated has been cast. Continue rubbing until entire

surface is of smooth texture and uniform color. After final rubbing is completed and surface has dried, rub with burlap to remove loose powder and objectionable marks.

3. Number-3 Broomed Finish:
 - a) Where floors and other areas are shown to have rough finish, strike-off surface with screeds and wood floats at elevation shown.
 - b) Before concrete has achieved initial set, broom transversely to flow of traffic with stiff, medium-bristle broom especially made for intended purpose to develop corrugations not more than 1/8-inch deep.
4. Number-4 Steel-Troweled Finish:
 - a) Where floors are shown to have a steel-troweled finish, screed concrete to established grades and compact with wood or power-driven disc float.
 - b). After surface has hardened sufficiently, finish with steel trowel to dense hard finish, free of trowel marks.
 - c) Do not use dry cement or mixture of dry cement and sand to absorb water.
5. Number-7 Natural-Board Finish:
 - a) After stripping forms, cut back form ties as specified. Touch-up holes created by form ties and damaged or defective finish using grout closely matching surrounding concrete. Accomplish grouting and repairs as specified. Knock-off heavy elongated fins, but do not rub down.

3.10 DEFECTIVE CONCRETE:

- A. Concrete will be considered defective unless it is structurally sound, watertight, properly finished and within specified tolerances.
- B. Concrete in place that is deemed structurally defective will be checked by the Authority Representative by drilled core specimens. If testing of core

specimens shows that strength is less than 85 percent of specified strength, costs incurred in taking and testing of core specimens will be done by the Contractor.

- C. Replace, strengthen or correct defective concrete as directed.

3.11 PROTECTION FROM AND REMOVAL OF STAINS:

- A. Protect concrete structure from rust staining by structural-steel members or from other substances during the work.
- B. If staining should occur, remove stains and restore concrete to its original color.

3.12 DAMAGED WORK:

- A. Before final acceptance of the work, neatly repair damaged surfaces, corners of concrete and concrete finish.
- B. Where surface repairs are permitted, finish damaged areas to smooth, dense watertight condition.
- C. Replace concrete that is not satisfactorily repaired.

3.14 CORRECTIVE WORK:

- A. Submit corrective action patching procedure.
- B. If correction of defects is approved, remove defective concrete; key area to be repaired, soak surface with water and patch with approved materials. Patch architectural concrete so as to match existing. Use bonding agents applied to the substrate or mixed with patching material only as approved by the Authority Representative.
- C. Clean surface cavities produced by form ties, other holes, honeycomb spots, broken corners or edges and other defects. Saturate with water and point with mortar paste consisting of cement and fine aggregate mixed in proportions to give same appearance as original concrete.
- D. Prepare pointing mortar not more than 30 minutes prior to use. Cure mortar patches properly. Carefully tool contraction and articulated joints in completed work and keep them free of concrete. Where necessary, leave joint filler exposed for its full length with clean and true edges.

- E. Tolerance deviations and other surface defects may also be corrected, if approved, by grinding high areas and swales. Leaks in station electrical rooms, TPSS and TBS shall be epoxy injected.
- F. Where necessary or when directed, repair leakage in excess of specified maximum allowable, by means of contact grouting, chemical grouting or other approved means.
- G. Where corrective work is unsatisfactory, completely remove such work and replace with new work complying with specified requirements.

3.15 EPOXY MORTAR REPAIRS:

A. Surface Preparation:

1. Remove defective concrete with chipping hammers or other approved equipment. To prevent removing extra material and causing cracks, saw-cut concrete area to be removed into maximum six-inch square checkerboard pattern 4-1/2 inches deep.
2. Prepare exposed concrete surface by sandblasting clean and allowing to dry thoroughly. Surface drying may be accomplished by air jet. Ensure that compressed air used in cleaning and drying is free from oil or other contaminating materials.
3. Maintain concrete surface in sufficient depth at temperature of 65F minimum during first four hours after placement of epoxy bond coat. Preheating may be done with radiant heaters or other approved means. Do not preheat concrete in excess of 200F with final surface temperature below 105F at time of placing epoxy materials.

B. Application of Epoxy Bonding Agents:

1. Prepare epoxy bonding agent in accordance with manufacturer's recommendations.
2. Apply epoxy bonding agent to prepared dry concrete surface at coverage of 80 square feet per gallon maximum or as recommended by manufacturer.
3. Epoxy bonding agent may be applied by any convenient and safe method which will yield effective coverage, such as squeegees, brushes or rollers.
4. During application of epoxy bonding agent, ensure that material is confined to area being bonded; avoid contamination of adjacent surfaces. Extend epoxy bond coat slightly beyond edges of repair area.

C. Application of Epoxy Mortar:

1. Mix epoxy components in accordance with manufacturer's recommendations.
2. Proportion: 5-1/2 parts sand by weight to one-part epoxy.
3. Mix components with slow-speed mechanical device.
4. Prepare mortar in small batches so that each batch can be completely mixed and placed within approximately 30 minutes.
5. Do not add thinners or dilutants to mortar mixture.
6. Immediately after application of epoxy bonding agent, place, tamp, flatten and smooth epoxy mortar.
7. Work mortar to grade.
8. Steel-trowel finish. Trowels may be heated to facilitate finishing.

D. Curing:

1. Cure epoxy mortar repairs immediately after completion at 60F minimum until mortar is hard.
2. Initiate post-curing of four hours minimum at surface temperature of 90F minimum, 110F maximum.
3. Heat may be applied by using portable propane heaters, infrared heaters or other approved sources positioned to attain necessary surface temperature.
4. Do not subject epoxy-bonded epoxy mortar to moisture until after specified post-curing has been completed.

3.16 CONCRETE OVERLAYS AND TILE SETTING BEDS:

A. General:

1. Water blast (3,000 - 5,000 psi) or sand blast the substrate.
2. Keep slabs continuously wet for 24 hours prior to concrete placement.

Substrate to be air blown just prior to concrete placement.

3. Place concrete in two pours of equal thickness. Place welded-wire-fabric reinforcement on first pour and then place second pour.
4. Use a vibratory screed on overlays.
5. Float slab and apply light broom finish. Cure slabs with water.
6. Remove laitance by methods in number one above if the overlay requires a bonding surface for tile or other treatments.
7. Continuously moist cure of overlay (setting bed) for seven (7) days.

* * *

END OF SECTION

SECTION 04050

MORTAR, GROUT AND MASONRY ACCESSORIES

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. This section specifies furnishing mortar, grout, and accessories for masonry work, including brick masonry, concrete unit masonry, granite and other stone masonry. The installation of such material is specified in the various masonry sections.
- B. Related Work Specified Elsewhere:
 - 1. Concrete unit masonry: Section 04220.

1.2 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Shop Drawings:
 - 1. Manufacturer's data: Recommendations for use of materials, preparation of substrate, limitations and special instructions for materials necessary to the work.
- B. Samples:
 - 1. Three of each type of the following products used in the work:
 - a) Mortars: Cured samples showing color of each type.
 - b) Accessories: Representative samples of each type.
- C. Certification.

1.2 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
 - 1. Comply with codes and regulations of the jurisdictional authorities.

2. ASTM: A36, A82, A153, A276, A666, A775, C114, C144, C150, C207, C270, C476, C665, C780, C881, C1019, D570, D638, D695, D1525, D2000, D2240, F593, F594.
 3. FS: HH-I-521
- B. Source Quality Control:
1. Obtain mortar ingredients of a uniform quality, including color for exposed masonry, from one manufacturer for each cementitious component and from one source or producer for each aggregate.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver products to job site in their original unopened containers clearly labeled with manufacturer's name and brand designation, referenced specification number, type and class as applicable.
- B. Store products so as to prevent water intrusion, dampness and deterioration. Store loose materials sand and aggregates so as to prevent intrusion of foreign materials.
- C. Handle products so as to prevent breakage of containers and damage to products.

1.5 JOB CONDITIONS:

- A. Environmental Requirements:
 1. Do not use materials or aggregates that are covered with frost. Do not mix mortar when the temperature is below that specified for masonry work.
 2. Provide protective covering and heat as specified for masonry work.
 3. Perform work under environmental conditions consistent with manufacturer's recommendations for materials being used in the work.

PART 2 - PRODUCTS

2.1 MORTAR AND GROUT MATERIALS:

- A. Cement:
 1. ASTM C150, Type I, portland cement, packaged in one-cubic-foot waterproof bags.
 - a) For exterior walls, use low alkali cement; maximum 0.60 percent total alkali when tested according to ASTM C114.
 - b) For below grade use type II cement and lime.

2. Cement for brick masonry:

- a) Factory-prepared, color-blended with nonstaining, inorganic coloring pigment.
- b) Pigments not to exceed 10 percent of weight of cement.
- c) Pigment blended in such quantity to produce cured mortar color matching face brick when mixed with hydrated lime and fine aggregate.

B. Hydrated Lime:

- 1. ASTM C207, Type S.
- 2. Uniform color for similar work.

C. Fine Aggregate: Clean, sharp, masonry sand, ASTM C144. For joints less than 1/4 inch, grade aggregate with 100 percent passing the Number 16 sieve.

D. Water: Potable.

E. Pigment: As necessary to produce colored mortar matching color of brick unless otherwise indicated.

F. Admixtures: Do not add admixtures including air-entraining agents, accelerators, retarders, water repellent agents, antifreeze compounds, or other admixtures unless otherwise indicated.

G. Epoxy for Epoxy Mortar: Two-component, ASTM C881, Type 3, Grade 3, Class C, with the following additional requirements:

- 1. Component A: Modified-epoxy resin of epichlorohydrin bisphenol A-type, containing suitable viscosity control agents and having epoxide equivalent of 180-200.
- 2. Component B: Primarily reaction product of aromatic amine and an aliphatic amine with epoxy resin of epichlorohydrin bisphenol A-type.
- 3. Ratio of Component A to Component B: By volume, 1:2.
- 4. Properties of mixed components:
 - a) Solids content: 100 percent by weight.
 - b) Pot life: 20 to 30 minutes at 73F.

- c) Tack-free time, thin film: Two to four hours at 73F
- d) Final cure, 75-percent ultimate strength, ASTM D695: Two days at 73F.
- e) Initial viscosity, A plus B: 250 to 350 cps at 73F.

5. Properties of cured material:

- a) Tensile strength, ASTM D638: 5,000-psi minimum at 14 days, 73F cure.
- b) Tensile elongation, ASTM D638 modified: One to three percent at 14 days, 73F cure.
- c) Compressive strength, ASTM D695: 10,500-psi minimum at 28 days, 73F cure.
- d) Water absorption, ASTM D570: One-percent maximum.
- e) Bond strength: 2,000-psi minimum at 14 days.
- f) Hardened to hardened: 73F cure.
- g) Vicat softening temperature, ASTM D1525: 121F minimum.

G. Aggregate for Epoxy Mortar: Silica sand, Size 20 to Size 40, dust-free and moisture-free.

2.2 MORTAR AND GROUT MIXES:

A. Mortar Mixes for Brick Masonry: ASTM C270, types as follows:

- 1. Type S: For exterior loadbearing masonry and for masonry in contact with earth, proportioned by volume as follows:
 - a) Portland cement: One part.
 - b) Hydrated lime: 1/4 to 1/2 part
 - c) Fine aggregate: Not less than 2-1/2 nor more than three times sum of volumes of cement and lime.
 - d) Pigment: As necessary to produce colored mortar matching color of brick unless otherwise indicated.
- 2. Type N: For interior non loadbearing masonry, proportioned by volume as specified for e Type S, except 1/2 to 1-1/4 parts hydrated lime.

- B. Mortar Mixes for Concrete Unit Masonry: As specified for brick masonry, except pigment not required.
- C. Grout: For setting steel lintels and similar items, grouting mortar composed of one-part portland cement and two parts fine aggregate with sufficient lime putty added to obtain quick set.
- D. Preshrunk Mortar: Dry, premixed, ready-to-use formulation.

2.3 ACCESSORIES:

- A. Accessories for Brick and Concrete Unit Masonry:
 - 1. Continuous joint reinforcement:
 - a) Prefabricated continuous-reinforcing tie system fabricated of wire conforming to ASTM A82. Flush-welded cross ties, nine-gauge wire, hot-dip galvanized after fabrication in accordance with ASTM A153, Class B2, 1.50 ounces for side and cross rods.
 - b) Fabricate joint reinforcement in straight lengths of not less than 10 feet of truss design with continuous diagonal cross ties spaced maximum 16 inches o.c.
 - (1) Make width of unit 1-1/2 inches to two inches less than thickness of wall.
 - (2) For multi-wythe wall, provide one side rod for each face shell of masonry more than four inches in width; plus one side rod for each wythe of masonry four inches or less in width.
 - (3) At cavity walls, provide integral drips on cross rods.
 - (4) Where horizontal joints of outer wythe does not align with back-up joints, provide adjustable two-piece tab design to engage the outer wythe by at least 1-1/2 inches.
 - c) Corner reinforcement: Prefabricated, shop-welded corner-L and intersection-T units matching the continuous wall units.
 - d) Spacing: See related work sections.
 - 2. Dovetail anchors:
 - a) Flexible, adjustable or corrugated 1-inch wide dovetail anchors of 12 gauge galvanized steel. Place anchors every 16 inches in height of wall at intersections

of masonry walls and concrete, and for masonry furring of concrete. Dovetail slots are specified in Section 03100, by same manufacturer of anchors.

3. Wall plugs:
 - a) Galvanized 26-gauge corrugated metal, approximately three inches long and of standard manufacture, where necessary for attaching other work.
 4. Z-type rigid-steel anchors: Steel, ASTM A36, 1/4-inch thick by 1-1/2 inches wide by 28 inches long, galvanized; with one two-inch opposing 90-degree bend at each end.
 5. Corrugated-steel anchors: 14 gauge by 1-1/4 inches by 20 inches with one two-inch 90-degree bend, with 18 inches of corrugation.
 6. Steel framing anchors: Fabricated of 3/16-inch galvanized wire tie and galvanized flat- steel strap one-inch wide by 22 gauge or 3/4-inch wide by 12 gauge.
 7. Weep-hole tubes: 3/8-inch OD, medium density, nonstaining, polyethylene tubes of lengths ensuring complete panel penetration and unobstructed flow.
 8. Fire-resistant compressible filler: Inorganic, non-asbestos mineral fibersafing insulation, with foil facing to impede smoke passage; moisture resistant, mildew-proof and vermin-proof, noncorrosive and nondeteriorating; UL-listed; meeting ASTM C665 and FS HH-I-521 Type III, except for identification marking.
 9. Control joint gasket: Solid styrene-butadiene-rubber compound per ASTM D2000, 2AA-805, factory extruded into shapes for use with standard sashblock to provide stability to masonry walls at expansion and control joints; minimum shear strength 540 psi, durometer hardness 80 (plus or minus 5) per ASTM D2240. Provide T-shape and X-shape for vertical joints as appropriate, flat shape beneath load-relieving angles.
 10. Cavity Drainage System: 1 inch thick by 10 inches high by 5 feet long section of high density polyethelene or nylon mesh designed to allow moisture to flow downward in cavity joint.
- B. Masonry lintels: Section 04220.

PART 3 – EXECUTION

3.1 MIXING OF MORTAR:

- A. Mix mortar materials in an approved clean mechanical mixer for at least three minutes and not more than five minutes with a minimum amount of water to produce workable consistency.
- B. Mortar which has stiffened because of evaporation of water may be retempered by adding water as needed to restore necessary consistency. Use mortar within 2-1/2 hours of initial mixing.
- C. Use an approved method of measuring materials and mortar that will control and accurately maintain specified proportions throughout the work. Shovel measure is prohibited. Measure sand in damp, loose condition.

- D. Apply pre-shrunk mortar in accordance with the manufacturer's instructions.
- E. For alteration and restoration work, tint or modify mix to match mortar of existing masonry.
- F. The Authority Representative may direct a test of the mortar in accordance with ASTM C780 and a test of the grout for compressive strength per ASTM C1019 to establish compliance with specified requirements.

END OF SECTION

SECTION 04220

CONCRETE UNIT MASONRY

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. This section specifies providing concrete unit masonry and glazed concrete masonry.
- B. Related Work Specified Elsewhere:
 - 1. Mortar, grout and masonry accessories: Section 04050.

1.2 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Samples for Initial Selection: Samples in small-scale form showing the full range of colors and textures available for each different exposed masonry unit required.
- B. Samples:
 - 1. Three sets of each type of the following products used in the work.
 - a) Concrete masonry units (CMU):
 - (1) Lightweight.
 - (2) Special shapes.
 - b) Precast lintels.
 - c) CMU lintels.
- C. Shop Drawings: Show fabrication and installation details for the following:
 - 1. Reinforcing Steel: Detail bending and placement of unit masonry reinforcing bars. Comply with ACI 315, "Details and Detailing of Concrete Reinforcement." Show elevations of reinforced walls.

D. Certification.

1.2 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of the jurisdictional authorities.
2. NCMA: TEK Manual for Concrete Masonry Design and Construction.
3. ASTM: A615, C33, C55, C90, C129, C150, C744, E119.
4. ACI: 315, 530.1-99.
5. UL: Fire Resistance Directory.

B. Source Limitations for Masonry Units: Obtain exposed masonry units of a uniform texture and color, or a uniform blend within the ranges accepted for these characteristics, through one source from a single manufacturer for each product required.

C. Fire-Resistance Ratings: Where indicated, provide materials and construction identical to those of assemblies with fire-resistance ratings determined per ASTM E119 by a testing and inspecting agency, by equivalent concrete masonry thickness, or by another means, as acceptable to authorities having jurisdiction.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver products to jobsite in good condition.
- B. Keep products clean and dry. Prevent contact with soil.
- C. Handle products so as to prevent chipping and breakage.

1.5 JOB CONDITIONS:

A. Environmental Requirements:

1. The following are prohibited:
 - a) Use of products that are covered with frost.

- b) Erection of masonry when the temperature is below 40F or tending to fall below 40F, unless suitable fireproof protection covering and heat are provided to maintain work and materials above 40F.

PART 2 - PRODUCTS

2.1 MATERIALS:

A. CMU:

1. General:

a) Nominal dimensions:

- (1) Face size: 7-5/8 inches by 15-5/8 inches, 3-5/8 inches by 15-5/8 inches.
- (2) Thickness: As shown.

- b) For exposed work, units of uniform medium texture, free from defects and of uniform dimensions. Furnish special units as necessary.
- c) Units having UL Fire Resistance Directory ratings to achieve fire ratings for walls as required by local building codes and as shown.
- d) Units free from iron and other substances that will stain plaster or paint.

2. Lightweight CMU:

- a) Hollow, lightweight loadbearing concrete units: ASTM C90, Type I.
- b) Solid, lightweight loadbearing concrete units: ASTM C90, Type I.
- c) Lightweight concrete brick: ASTM C55, Type I, Grade N.
- d) Aggregate: Limited to expanded shale or slate.
- e) Hollow, light-weight non-load bearing concrete units: ASTM C129, Type 1.

3. Normal-weight CMU:

- a) Solid loadbearing units: ASTM C90, Type I.

4. Exposed alteration and restoration work: Units of same type, grade, size, color variation, texture and appearance as existing masonry work.
5. Concrete fill for CMU bond beams and reinforced masonry unit cores: Class 3500; maximum aggregate size, 3/4 inch, and in accordance with Section 03300.
 - B. Masonry Accessories: Section 04050.
 - C. Mortar and Grout: Sections 04050.

PART 3 - EXECUTION

3.1 PREPARATION:

- A. Clean foreign substances which would affect bond of mortar from surfaces to receive CMU.
- B. Built-In Work.
 1. Verify locations of chases and openings for pipes, conduits and ducts.
 2. Establish locations for walls and partitions; verify that door frames and other built-in work provided by others are or can be properly located.

3.2 ERECTION:

- A. Erect exposed CMU masonry work to conform to approved sample panel.
- B. Use of loadbearing and non-loadbearing units shall be governed by locations and purposes to be served. Except as otherwise shown, follow these general uses:
 1. Non-loadbearing: Furring, non-bearing partitions and backup non-loadbearing masonry walls.
 2. Solid: Where specifically required by drawings, for fireproofing structural steel and for partitions with fire ratings.
- C. Erect adjoining walls simultaneously. Do not erect walls more than five feet above adjoining walls. Toothing is prohibited. Cover and protect the tops of unfinished walls.
- D. Plumb piers, walls and partitions. Level courses using uniform joint thickness for interior work, build external corners with bullnose units.
- E. Place reinforcement and build in openings for pipes, conduits, ducts, chases, frames and

other work as shown.

- F. Grout in accordance with Sections 04050 and set in place miscellaneous steel lintels furnished by other trades for openings in masonry walls in accordance with approved shop drawings. Provide eight-inch minimum bearing on adjacent masonry unless otherwise indicated.
- G. As the work progresses, keep masonry clean by stiff brushing with fiber brush.
- H. Do not wet units before laying up. Lay units in running bond.
 - 1. Set cored units with cells vertical, unless manufactured with horizontal cores. Open ends not permitted.
 - 2. Lay out so that at jambs and internal and external angles, the headers in alternate courses are at least 2 inches long. Use "Z shapes if necessary , especially with glazed masonry units.
 - 3. Lay units out so that no cut piece is less than 5 inches long; not less that 2 inches high.
 - 4. Lay concrete units up suitable for painting. See finish schedules.
- I. Prevent smearing mortar on surface of exposed units. If mortar smears occur, remove while soft.
- J. Carefully cut faces of units for electrical or other outlets and cut-out backs for conduit and other piping. Where possible, use full-size units. Do not use portions of units shorter than four inches. Perform cutting with power-driven masonry saws.
- K. Build partitions straight, plumb, true to line and uniform in thickness unless shown otherwise. Anchor partitions at junctions with CMU exterior walls using Z-type steel anchors, rigid or corrugated, Z-bar anchors vertically 24 inches on center maximum unless otherwise shown. Use dovetail anchors spaced not over 16 inches on vertical centers where partitions abut concrete walls or concrete columns and steel framing anchors where partitions abut steel columns. Start partitions on concrete slabs and extend to structure above, except where shown to be erected only to ceiling.
- L. Use CMU or precast lintels except where steel lintels are shown. Use precast lintels for four-inch CMU partitions. For other CMU partitions and walls, use lintels fabricated at plant or at jobsite from concrete-masonry lintel units. Provide eight-inch minimum bearing on adjacent masonry unless otherwise indicated.
- M. Fill cells of CMU with mortar in accordance with Section 04050, adjacent to openings and around built-in and embedded items.

- N. Place prefabricated continuous joint reinforcement in alternate horizontal joints above grade and each horizontal joint below grade. Terminate each side of expansion joints. Use specially fabricated sections at corners and intersections.
- O. Fill cells solid with grout in accordance with Sections 04050 where vertical reinforcement is installed within CMU walls.
- P. Fill heads and jambs of hollow metal frames solid with mortar in accordance with Section 04050, as laying of units progresses.
- Q. Tooling joints:
 - 1. Soon after mortar has attained initial set, finish and compact with non-staining metal jointing tool, forcing mortar tight against masonry units and closing all hair line cracks and crevices.
 - 2. Interior and exterior joints tooled concave type, except as stated below or noted otherwise.
 - a) At wall faces to receive other facing materials having mortar backing, strike joints flush.
 - b) At concealed joints and joints on cavity side of cavity walls, strike flush.
- R. Mortar Bedding in accordance with Section 04050:
 - 1. Hollow units shall be laid with full mortar coverage on horizontal and vertical face shells, except that webs shall also be bedded in all courses of piers, columns, and pilasters, and in the starting course of footings and solid foundation walls, and where adjacent to cells or cavities to be reinforced and/or filled with mortar or grout.
 - 2. Solid units laid with full head and bed joints.
 - 3. Masonry units:
 - a) Laid in beds of mortar of such plasticity and fullness and spread with trowel so that pressing and shoving units will obviate dashing or slushing joints after units are laid. Mortar shall not be "furrowed".
 - b) In cavity walls, mortar shall be beveled on cavity side to prevent protruding mortar fins and subsequent dropping of mortar into cavity.
 - c) For interior and exterior faces of walls, prior to placing units, one end of each stretcher shall be fully covered with mortar.
 - d) For any wall thickness, leave no voids whatever, except space in cavity walls.
- S. Top of Non-Loadbearing Partitions: Build non-loadbearing interior partitions full height of story to underside of solid floor or roof structure above, unless shown otherwise. Build as follows

depending on the movement requirements of floor or structure above, and as shown:

1. Install fire resistant compressible filler in joint between top of partition and underside of structure above.
2. Fill top joint with mortar in accordance with Section 04050, after dead-load deflection of structure above approaches final position.

T. Installation of Masonry Accessories:

1. Wall anchors:
 - a) Space Z-type rigid-steel anchors at intersections of loadbearing CMU walls and control joints.
 - b) Space corrugated-steel anchors 16 inches on centers vertically at control joints located not more than two feet from intersections of CMU walls.
2. Steel framing anchors: Install anchors to attach CMU walls to structural steel building frame at 16 inches on centers horizontally and vertically. Weld anchors to structural steel so as to achieve full strength of anchor system.
3. Soldier-course anchors: Install corrugated-steel anchors in horizontal mortar joints of soldier coursing, except where continuous wall reinforcement is used. Space anchors 24 inches on centers horizontally.
4. Flashing: Install flashing to provide positive keying to mortar.
5. Weep holes: Install at two feet on centers at terminations of through-wall flashing, base flashings, lintels, or relief angles, and as shown.
6. Control joint gasket: Install in sash-type CMU and between wythes in accordance with manufacturer's instructions and as shown. Seal weather side of control joints with sealant and backup rod.

U. Bond Beams:

1. Provide bond beams in walls where shown.
2. Construct similar to CMU lintels, except beams to be continuous, except at control joints.

3.3 POINTING AND CLEANING:

A. Pointing:

1. When approved, point holes in joints of exposed CMU masonry surfaces by completely filling with preshrunk mortar.
2. Point exposed raked joints of CMU masonry with mortar and tool to match approved samples panels.

B. Cleaning:

1. After pointing, wet and clean exposed CMU masonry surfaces with soap-and-water solution, applied with stiff-fiber brushes leaving masonry clean, free of mortar daubs and with tight mortar joints throughout. The use of acid is prohibited.
2. Allow masonry walls to cure at least three weeks in summer and five weeks in winter before cleaning.
3. Begin cleaning at top and work down.
4. Remove as much mortar from masonry as is possible by hand with wooden paddles and nonmetallic scraper hoes or chisels or stiff bristle brushes taking care not to deface masonry units.
5. Remove specific stains by cleaning method indicated in NCMA TEK 8-2 applicable to type of stain present on exposed surfaces.
6. Clean surfaces thoroughly and carefully with specified cleaning solution.
7. Rinse and flush with clean water immediately after cleaning.
8. Leave work in clean condition, free from mortar stain or other defacement.

* * *

END OF SECTION

SECTION 05120

STRUCTURAL STEEL

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. This section specifies structural steel work.
- B. Options:
 - 1. Substitution of rolled shapes for welded sections and vice versa is permitted, provided that shapes and sections to be substituted are approved and comply with the following:
 - a. Keep depth, width, average or mean thickness, web shear area, moments of inertia, torsional constant and warping constant to be at least equal to those for shape or section shown. Maintain clearances and other dimensions shown as critical.
 - b. Have steel shapes, plates and bars conform to same ASTM designation as material for which substitution is made.
- C. Related Work Specified Elsewhere:
 - 1. Finish painting for structural steel: Section 09920.

1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
 - 1. Comply with codes and regulations of the jurisdictional authorities.
 - 2. AWS: D1.1.
 - 3. AASHTO: Interim 1981 Fracture Control Plan; Standard Specifications for Highway Bridges, including supplements. Where conflict occurs between AWS and AASHTO, AASHTO governs.
 - 4. AISC:
 - a) Specification for Structural Steel Buildings-Allowable Stress Design and Plastic Design.
 - b) Manual of Steel Construction-Allowable Stress Design.
 - c) Code of Standard Practice for Steel Buildings and Bridges.
 - d) Allowable Stress Design Specification for Structural Joints using ASTM A325 or A490 Bolts.
 - e) Specifications for Architecturally Exposed Structural Steel.
 - 5. ASNT: Recommended Practice SNT-TC-1A.
 - 6. SSPC: SP-6, SP-10.

7. ANSI: B27.2.
8. MS: MIL-P-21035.
9. FS: TT-P-645
10. ASTM: A6, A27, A36, A108, A109, A123, A148, A153, A242, A307, A325, A370, A449, A490, A500, A501, A514, A517, A572/572M, A588, A668, A673, A709, A780, B663, B766.

B. Source Quality Control:

1. Testing and inspection:

a) Nondestructive-test requirements for welded members:

(1) Perform the following:

- (2) Tension butt welds in fracture-critical nonredundant members and member components of structures subject to repetitive dynamic loading: 100 percent of welds inspected by radiographic and ultrasonic examination.
- (3) Butt welds of flange material for compression and tension splices: 100 percent of welds inspected by ultrasonic examination.
- (4) Butt welds for web splices beginning at point of maximum stress: 40 percent of welds inspected by ultrasonic examination.
- (5) Fillet welds connecting web plates to flange plates: 25 percent of welds inspected by magnetic particle inspection.
- (6) For all other fillet-weld connections: 10 percent of welds inspected by magnetic particle inspection.
- (7) The Engineer may designate additional items to be inspected by radiography.

b) Mill testing:

- (1) For identified stock materials provide three specimens from each heat number, one for tension test, one for bend test and one for Charpy V- notch impact test.
- (2) Cut, machine and test specimens in accordance with ASTM A370.
- (3) Perform Charpy V-notch impact test for tension flanges and other tension components of aerial structures in accordance with Table 05120-1.

c) Bolts:

- (1) The Engineer will randomly select at least five bolts for test purposes from each bin of bolts furnished.

C. Qualification of Welding Personnel and Procedures:

1. Prior to qualifying welding personnel and welding procedures, confirm an agreement with the Engineer as to procedural details, sequence of welding, handling of materials to be inspected, and approval of electrodes, wire, flux and other welding materials and equipment.
2. Employ welding personnel whose qualification is certified in accordance with AWS D1.1. Such certification is to remain in force for the duration of the welding operations under this Contract.
4. Do not start fabrication until qualification has been successfully completed.

D. Qualification of Nondestructive-Testing Personnel:

1. Nondestructive testing of fracture-critical members to be conducted by personnel qualified as NDT Level II or Level III in accordance with ASNT SNT-TC-1A.
3. Level-II technicians to be supervised by Level III-personnel.

E. Stock Material:

1. For qualification of welding personnel and procedures and for quality-assurance testing, use only stock materials which can be identified as having been rolled from a given heat and for which certified mill tests can be produced.
2. When stock material is proposed, inform the Engineer of such intention at least 10 days in advance of commencing fabrication to permit sampling and testing. Select identified material from as few heats as possible.

F. Welder's Identification Mark (for Fabrication Shops):

1. Assign each welder and welding operator an identification mark to stamp on pieces he has welded.
2. Have welder or welding operator place his identification mark by metal-die stamp in letters 3/8-inch high in position that identification of welder or operator will appear adjacent to each of his welds in finally assembled members for ready reference to radiographic films and for identification by the Engineer.

G. Elevator Hoistways:

1. Fabricate framing not to exceed 1/8-inch deviation from dimensions shown throughout. Perform straightening where necessary.

1.03 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

A. Shop Drawings:

1. Structural details: Include the following:
 - a) Bills of materials giving complete information for fabrication and erection of component parts of structures including material and finish information.
 - b) Details of location, type, sizes of bolts and welds and for welded structures details of welding as specified.
 - c) Structural computations for Contractor-designed work certified by a professional engineer registered in the jurisdiction where the work is to be performed.
2. Match marks:
 - a) Provide diagram showing match marks for connecting structural parts assembled in shop for purpose of drilling or reaming holes in field connections.
3. Welding:
 - a) Complete shop details of qualification test specimens.
 - b) Include information on specimen identification, number of pieces and welding procedure specification, type of material, sizes of pieces and welds and other variables affecting detail or tests.
4. Erection Plan:
 - a) Details of methods of erection proposed to be used, including calculated stresses for proposed erection certified by a professional engineer registered in the jurisdiction where the work will be performed. Do not proceed until approval has

been received.

5. Manufacturer's test procedures for bolts.
 - B. Certification:
 1. Certified mill test reports of structural steel at least 10 days prior to start of fabrication.
 2. Certified quality-assurance testing and inspection reports.
 3. Certification verifying that welding personnel have been qualified in accordance with AWS D1.1 and as specified above under Qualifications of Welding Personnel and Procedures.
 4. Manufacturer's certification that bolts meet approved testing.
 5. Certification of nondestructive-testing personnel.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. General:
 1. Load, transport, unload and store structural materials so as to keep them clean and free from damage.
 2. Store material on platforms, skids or other supports above the ground and ensure proper drainage and protection from corrosion.
- B. Steelwork:
 1. When handling and shipping steelwork, prevent bending, scraping or over stressing members.
 2. Block projecting parts likely to be bent or damaged during handling with wood or other approved material
 3. Replace pieces bent or damaged unless repair is approved.
 4. Indicate weight on members weighing more than three tons by means of paint contrasting with shop coat.
- C. Bolts and Nuts:

1. Ship small parts such as bolts, nuts, washers, pins, fillers and small connecting plates or angles in boxes, crates or barrels.
2. Pack separately bolts of each length and diameter and loose nuts or washers of each size.

D. Paint:

1. Have paint materials delivered in manufacturer's original sealed containers, bearing manufacturer's label and name, specification identification number where applicable as well as month and year of manufacture.

1.05 JOB CONDITIONS:

A. Environmental Requirements:

1. Welding:
 - a) When welding during cold weather, avoid chilling weld metal within zone of welding influence and avoid restraining manual functions of welder or welding operator.
 - b) When temperature where steel is stored is more than 20F below that of welding shop, move steel to be welded into shop sufficiently in advance of welding to allow it to attain shop temperature prior to welding.
 - c) Steel to be free of moisture. Dry as necessary by application of heat not exceeding 100F.
 - d) Do not weld when shop temperature is below 40F.
2. Painting:
 - a) Apply paint when temperature of steel and paint is above 40F and temperature is forecast to remain above 40F until paint has dried.
 - b) Painting steel at a temperature which can cause blistering, porosity or conditions otherwise detrimental to life of paint is prohibited. When paint is applied in hot weather or thinned in cold weather, ensure that specified thickness of paint coating is obtained.

- c) Application of paint in rain, wind, snow, fog or mist or when steel surface temperature is below dew point is prohibited, unless otherwise approved. If painting in damp or cold weather is unavoidable, provide protective covering and heat steel and surrounding air to 40F minimum. Maintain this temperature until weather conditions permit discontinuance.

PART 2- PRODUCTS

2.01 MATERIALS:

- A. General Requirements for Rolled-Steel Plates, Shapes and Bars:

ASTM A6.
- B. Carbon-Steel Plates, Shapes and Bars: ASTM A36, ASTM A709,

Grade 36.
- C. High-Strength, Low-Alloy, Structural-Steel Plates, Shapes and Bars: ASTM A242.
- D. High-Strength, Low-Alloy, Structural, Columbium-Vanadium Structural Steel: ASTM A572/A572M.
- E. Corrosion-Resistant Structural Steel: ASTM A242., A588
- F. High-Strength, Low-Alloy, Corrosion-Resistant Structural-Steel Shapes, Plates, and Bars: ASTM A588.
- G. Low-Carbon Steel Bolts and Nuts: ASTM A307, Grade A or B.
- H. High-Strength Carbon-Steel Bolts, Nuts and Washers for Structural Joints: ASTM A325; for bolts over one-inch diameter, ASTM A449.
- I. High-Strength Alloy-Steel Bolts, Nuts and Washers for Structural Joints: ASTM A490.
- J. Round Washers Other Than Those In Contact With High-Strength Bolt Heads and Nuts: ANSI B27.2, Type B.
- K. Beveled Washers:

1. Square, smooth and sloped to make contact surfaces of bolt head and nut parallel.
 2. Diameter of hole in square beveled washers as follows:
 - a) For bolts less than one-inch diameter: 1/16-inch larger than bolt size.
 - b) For bolts larger than one-inch diameter: 1/8-inch larger than bolt size.
- L. Carbon-Steel Forgings: ASTM A668, Class C.
- M. Alloy-Steel Forgings: ASTM A668, Class G.
- N. Structural-Steel Tubing:
1. Structural framing for elevator hoistways: ASTM A500, Grade B.
 2. Other structural tubing: ASTM A501.
- O. High-Strength Steel Casting: ASTM A148, metal type as shown.
- P. Mild-To-Medium-Strength Carbon-Steel Castings: ASTM A27, grade as shown.
- Q. Shear Connectors:
1. Cold-rolled carbon-steel strip.
 2. Stud-welding fasteners with upset head developing tensile strength of 65,000 psi- minimum and yield strength of 52,000-psi minimum.
 3. Complying otherwise to the following:
 - a) Cold-finished bars, Grade 1015, Grade 1018 or Grade 1020, semi-killed or fully killed: ASTM A108.
 - b) Low-carbon steel suitable for welding: ASTM A109.
 4. Stud welding conforming to AWS D1.1.

5. Sizes and shapes: As shown.
 6. Lengths to be after-weld lengths.
 7. Studs arc-welded to parent metal as shown.
 8. Before welding, parent-metal surface to be free from rust, oil, paint, plating and other foreign matter.
 9. Heat treat parent metal where needed to develop full weld strength.
- R. Galvanizing:
1. Steel products specified as galvanized to be hot-dip galvanized after fabrication in accordance with the following:
 - a) Zinc coatings on products fabricated from rolled, dressed and forged steel shapes, plates and strips: ASTM A123.
 - b) Zinc coating on iron and steel hardware: ASTM A153.
 - c) Zinc coating on assembled steel products: ASTM A123.
 - d) Zinc-coating weight: Two ounces per square foot minimum.
 - e) Zinc-dust zinc-oxide primer conforming to MS MIL-P-21035 applied in accordance with ASTM A780 in two coats for repairs to damaged surfaces after removal of loose or cracked zinc coating.
- S. Electroplated Zinc Coating: ASTM B663 for type specified.
- T. Cadmium Plating: ASTM B766 for type specified.
- U. Paint for Shop Prime Coating: FS TT-P-645.
- V. Cleaning Solution: Muriatic acid solution, specific gravity 1.18, prepared in a solution of one-part muriatic acid and five parts water.

PART 3 - EXECUTION

3.1 FABRICATION:

- A. Workmanship and finish to best commercial practice accomplished in structural or

bridge shops.

B. Straightening Material:

1. Use rolled material that, before being laid off or worked, is straight within tolerances specified in ASTM A6.
2. Perform straightening where necessary by approved methods which will not overstress material.
3. Do not heat-shrink low-alloy structural steel.
4. Achieve fabrication tolerances which will result in full bearing.
5. Perform straightening, planing and connecting of portions of members in bearing assemblies and in direct bearing after fabrication as necessary to provide full bearing assemblies and bearing areas.

C. Cutting:

1. Flame-cut edges of members subject to dynamic loading by mechanically guided torch or by hand. Remove nicks by grinding to depth not exceeding 1/4 inch.
2. Shape re-entrant corners notch-free to radius of 1/2-inch minimum.
3. Perform flame cutting so that metal does not carry stress during cutting operation.
4. Direct flame so that remaining material is not damaged.

D. Planing and Facing:

1. Plane to depth of 1/4 inch sheared edges of plates more than 5/8-inch thick which will carry calculated stress.
2. Face and bring abutting joints to even bearing where shown.
3. Fabricate floor beams, stringers and girders having end connection angles to exact
4. length back-to-back of connection angles.
5. For compression joints depending on contact, prepare bearing surfaces to a common plane by milling, sawing or other approved means.

6. Where end connections are faced, ensure that finished thickness of angle is not less than that shown.

E. Bolt Holes:

1. Punch or drill holes for bolts.
2. Subpunch or subdrill and ream assemblies using steel template for alignment of connections as necessary. Flame cutting is prohibited.
3. Subdrill or subpunch holes 3/16-inch less than nominal diameter of bolt; drill or ream holes 1/16-inch greater than nominal diameter of bolt.

F. Connections:

1. Except where welded or ASTM A307 bolted connections are shown, use ASTM A325 or ASTM A490 bolts for shop connections.
2. Unless otherwise shown, bolt field connections using ASTM A325 or ASTM A490 bolts in accordance with AISC Specifications for Structural Joints.
3. Use of ASTM A490 bolts for dynamic or fluctuating loadings is prohibited.

G. Plates:

1. Bent plates: For load carrying cold-bent plates, use identified stock and arrange direction of bending at right angles to direction of rolling. Ensure radius of bend, measured on concave face of metal, is not less and preferably more than the following:

Angle of Plate Bend in Degrees	Minimum Radius
61 - 90	1.0T*
91 - 120	1.5T*
121 - 150	2.0T*

*T = Plate thickness.

2. Sheared plates: For gusset plates or connection plates, use sheared plates designed to resist applied loads in more than one direction in plane of plate.

3.02 WELDING:

- A. Perform welding in accordance with AWS D1.1.
- B. Perform procedure and sequence of welding so as to avoid needless distortion and to minimize stresses. Straighten transverse warpage of flanges, if necessary, by controlled heating along outside face.
- C. Make allowance in shop for expected weld shrinkage in laying out and assembling members. Trim members to size when most or all of welding has been completed.
- D. Complete butt welds in flange joints before flanges are assembled on web. Use extension blocks on such joints when making ends of butt welds, removing extension blocks only upon completion and cooling of weld. Ensure ends of welds are finished smooth and flush with edges of abutting parts. Use double-V-flange butt welds, unless otherwise shown. Back puddle all end craters.
- E. Make welds in web plates where shown.
- F. Prior to ultrasonic or radiographic testing of butt welds of flanges and webs, grind or machine weld reinforcement of joint to remove irregularities of weld surface so that it merges smoothly with base surface; one side for ultrasonic testing and both sides for radiographic testing.
- G. Ensure that welded joints which are to be radiographed are free of paint, scale and grease. Grind off welded ripples and surface irregularities on both sides of joint. Grind perpendicular to length of weld and to such a degree that resulting radiographic contrast due to remaining irregularities cannot mask or be confused with that of objectionable defect and so that weld surface will merge smoothly into adjoining surface.
- H. Repair defective welds by chipping or melting out such defects from one or both sides of joint removing no more weld metal than necessary to correct defect. Reweld and have weld retested radiographically.
- I. Welded Structures Subjected to Dynamic Loads:
 - 1. Do not use backup bars for fracture-critical nonredundant members or member components, as defined by AASHTO on Interim 1981 Fracture Control Plan.
 - 2. Avoid use of backup bars elsewhere, unless explicitly permitted by original design.
 - 3. When use of backup bars is unavoidable because of practicality but not explicitly permitted by original design, remove backup bar after welding

is completed and affected surfaces of weld metal and base metal is ground flush. Roughness of ground surfaces to be similar to that of surrounding unaffected plate surface.

3.03 BOLTING:

- A. Connections using high-strength steel bolts in accordance with AISC Specifications for Structural Joints using ASTM A325 or ASTM A490 bolts.
- B. Assemble high-strength bolted parts so that they fit solidly together when assembled. Do not use gaskets or other compressible materials.
- C. Remove scale, dirt, burrs and other defects likely to prevent proper seating when assembling joint surfaces, including those adjacent to washers.
- D. Remove oil, paint, lacquer and galvanizing from contact surfaces of friction joints.
- E. Use two nuts on unfinished bolts and turned bolts in tension.
- F. Tightening Bolts:
 - 1. Tighten ASTM A325 or A490 bolts to bolt tension not less than proof load given in AISC Specifications for Bolts.
 - 2. If approved, tighten by means of properly calibrated wrenches or turn-of-nut method.
 - 3. When tightening, place hardened washer under nut or bolt head, depending on which element is turned in tightening operation.
 - 4. Calibrate torque wrenches daily by tightening bolt assembly in device capable of indicating actual bolt tension.
 - 5. Install three bolts minimum from each lot.
 - 6. Nuts or bolts to be in tightening motion when torque is measured.
 - 7. Adjust power wrenches to cut-out or stall at required tension.
- G. Arrange bolts so that heads show in areas exposed to public view.

3.4 SHOP ASSEMBLY:

- A. Undertake complete or progressive shop assembly of continuous plate and box girders, rigid frames, bents and towers when shown. Obtain approval of

progressive shop-assembly procedure.

- B. Clean surfaces of metals in contact with each other with high speed wire brushes before assembling.
- C. Assemble parts to line and fit; drill or ream bolt holes while assembled. Hand reaming is prohibited unless approved.

3.5 SURFACE PREPARATION AND FINISHING OF STRUCTURAL STEEL:

- A. Clean steel surfaces in accordance with SSPC SP- 6 or SP-10.
- B. Shop Painting:
 - 1. Shop paint structural-steel work which will be left bare in finished structures.
 - 2. Do not shop paint the following:
 - a) Surfaces within three inches of joints to be field welded.
 - b) Galvanized surfaces and surfaces to be galvanized.
 - c) Contact surfaces: Apply rust-inhibitive treatment to such surfaces; remove by means of appropriate solvent prior to assembly.
 - c) Surfaces to be encased in concrete or in fire-protection material.
 - e) Weathering steel.
 - 3. Use paint-spraying equipment, if approved, with type of spray gun recommended by paint manufacturer for paint being applied.
 - 4. Use brushes of good quality bristle. Nylon brushes and roller coaters are prohibited.
 - 5. Neutralize areas of welding which are to be painted by applying specified cleaning solution. Wash neutralized area thoroughly with clean water and allow to dry before painting.
 - 6. Apply shop prime coat at minimum wet-film thickness of three mils. Give surfaces which will be inaccessible after assembly or erection three coats of paint before assembly.

7. Caulk small cracks, cavities and open seams around stiffeners and connections with pasty mixture of red lead and linseed oil or approved caulking putty and allow to dry before applying full shop coat.
8. Apply stripe coat of paint to edges, corners, bolts, welds and other sharp edges before giving steel full shop coat of paint. Apply stripe coat at least one-inch beyond area to be striped and allow to dry before applying full shop coat.
9. Paint erection marks and weight on each member after shop coat has dried.
10. Complete shop painting and ensure paint has completely dried prior to shipment of steel.

3.06 ERECTION:

- A. Install anchor bolts accurately in positions shown.
- B. If anchor bolts are cast in substructure masonry during its construction, ensure that each bolt is firmly held in its correct position and elevation by suitable templates.
- C. If approval is given for installing anchor bolts in preformed holes or in drilled holes in concrete or masonry, use approved nonshrink, nonstaining grout to secure them in place.
- D. Set bearing assemblies to lines and grades shown and adjust to horizontal position shown.
- E. Erect steel structures true and plumb following match marks.
- F. Use temporary bracing to support loads to which structures may be subjected including erection equipment and their operations. Leave bracing in place as long as safety requires.
- G. Report immediately to the Engineer errors in shop fabrication or deformation resulting from handling or transportation which prevent proper erection and fitting of parts.
- H. As erection progresses perform sufficient bolting of work to support dead load, wind load and erection load. Perform permanent bolting when enough alignment

has been accomplished to ensure that as much of structure as possible will be supported by such fastening work.

- I. Ensure that holes are not enlarged and that metal in vicinity of holes is not disturbed by drifting during assembly.
- J. Enlargement of holes to accept bolts for connections is prohibited unless approved. Make enlargement by reaming not by burning. Avoid hand reaming.
- K. Do not field weld main stress members.
- L. Bond premolded elastic filler with adhesive to structural framing at elevator hoistways.

3.7 NONDESTRUCTIVE TESTING OF FIELD WELDS:

- A. Perform pertinent testing specified for source quality control.

3.8 FIELD TOUCH-UP PAINTING:

- A. Retouch surfaces where shop coat has been damaged using paint and paint-film thickness identical to original shop coat.
- B. After erection, clean field bolts, nuts and adjacent areas and apply coat of paint identical to original shop coat.
- C. Finish painting for structural steel in accordance with Section 09920.

TABLE 05120-1				
BASE METAL CHARPY V-NOTCH REQUIREMENTS ^{*a} FOR FRACTURE-CRITICAL MEMBERS				
ASTM	Thickness, Inches (mm)	Zone 1 ^{*b}	Zone 2 ^{*c}	Zone 3 ^{*d}
A36	Up to 4 inches (101.6)	25 at 70F (33.9 Nm at 21.1C)	25 at 40F (33.9 Nm at 4.4C)	25 at 10F (33.9 Nm at minus 12.2C)

A572 ^{*e}	Up to 4 inches (101.6) mechanically fastened	25 at 70F (33.9 Nm at 21.1C)	25 at 40F (33.9 Nm at 4.4C)	25 at 10F (33.9 Nm at minus 12.2C)
	Up to 2 inches (50.8) welded	25 at 70F (33.9 Nm at 21.1C)	25 at 40F (33.9 Nm at 4.4C)	25 at 10F (33.9 Nm at minus 12.2C)
A588 ^{*e}	Up to 4 inches (101.6) mechanically fastened	25 at 70F (33.9 Nm at 21.1C)	25 at 40F (33.9 Nm at 4.4C)	25 at 10F (33.9 Nm at minus 12.2C)
	Up to 2 inches (50.8) welded	25 at 70F (33.9 Nm at 21.1C)	25 at 40F (33.9 Nm at 4.4C)	25 at 10F (33.9 Nm at minus 12.2C)
	Over 2 inches to 4 inches (50.8 to 101.6) welded	30 at 70F (40.7 Nm at 21.1C)	30 at 40F (40.7 Nm at 4.4C)	30 at 10F (40.7 Nm at minus 12.2C)
A514 ^{*f}	Up to 4 inches (101.6) mechanically fastened	35 at zero degree F (47.5 Nm at minus 17.8C)	35 at zero degree F (47.5 Nm at minus 17.8C)	35 at minus 30F (47.5 Nm at minus 34.4C)
	Up to 2-1/2 inches (63.5) welded	35 at zero degree F (47.5 Nm at minus 17.8C)	35 at zero degree F (47.5 Nm at minus 17.8C)	35 at minus 30F (47.5 Nm at minus 34.4C)
	Over 2-1/2 inches to 4 inches (63.5) welded	45 at zero degree F (61.0 Nm at minus 17.8C)	45 at zero degree F (61.0 Nm at minus 17.8C)	Not permitted

CVN impact testing to be P-plate frequency testing in accordance with ASTM A673. Code Charpy test pieces with respect to heat/plate number and record such code on mill-test report of steel supplier with test result. If directed, package broken pieces from each test (three specimens, six halves) and forward to the quality-assurance organization of the jurisdictional authority. Use average of three tests. If energy Value for more than one of three specimens is below minimum average requirements or if energy value for one of three specimens is less than 2/3 of specified minimum requirements, retest and obtain energy value from each of three retest specimens equal to or exceeding specified minimum average requirement.

Zone 1: Minimum service temperature zero degree F (minus 17.8C) and above.

Zone 2: Minimum service temperature from minus 1F to minus 30F (minus 28.3C to minus 34.4C). Zone 3: Minimum service temperature from minus 31F to minus 60F (minus 35C to minus 51.1C).

If the yield strength of the material exceeds 65 ksi (448.159MPa), reduce temperature for CVN value for acceptability by 15F (8.3C) for each increment of 10 ksi (68.947MPa) above 65 ksi (448.159MPa). Yield strength is value given in certified mill-test report.

ASTM A517 Charpy requirements are the same as for ASTM A514.

* * *

END OF SECTION

SECTION 05500

MISCELLANEOUS METAL

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. This section specifies providing miscellaneous metal, with the exception of ornamental (architectural) metal and metalwork provided as a part of mechanical, electrical and construction systems.
- B. Related Work Specified Elsewhere:
 - 1. Minor Repairs to Existing Concrete: Section 03900
 - 2. Access Doors and Frames: Section 08305
 - 3. Field Painting: Section 09920.

1.2 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Shop Drawings: Detail fabrication and erection of each metal fabrication indicated.
 - 1. Include plans, elevations, sections, and details of metal fabrications and their connections. Show anchorage and accessory items. Provide templates for anchors and bolts specified for installation under other Sections.
 - 2. Manufacturer's standard drawings may be submitted in lieu of Contractor-prepared shop drawings if manufacturer's standard drawings show required details.
- B. Certification:
 - 1. Certification that welding personnel are currently qualified in accordance with AWS D1.1.
 - 2. Mill Certificates: Signed by manufacturers of stainless-steel sheet certifying that products furnished comply with requirements for corrosion resistance of Type 316 stainless steel.

1.3 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of the jurisdictional authorities.
2. AWS: D1.1.
3. AISC: Specification for Structural Steel for Buildings-Allowable Stress Design and Plastic Design (Do not use plastic design).
4. SSPC: SP 11, Paint 12.
5. FED STD: 595.
6. MS: MIL-P-21035.
7. FS: A-A-462, FF-B-588, FF-H-116, FF-P-395, FF-S-325, RR-T-650, TT-P-86.
8. ASTM: A36, A53, A74, A108, A123, A167, A193, A229, A242, A276, A307, A313, A325, A413, A490, A501, A536, A570, A572, A588, A666, A780, A786/A786M, B 221, B 632, B633, D412, D1187, E488, F 593, F 594, F1554.
9. AGA: The Design and Fabrication of Galvanized Products.
10. ANSI: A14.3
11. ASME: A 17.1, B18.6.3, B18.21.1, B18.22.1.

B. Qualifications of Welding Personnel:

1. Welding: Qualify procedures and personnel according to the following:
 - a) AWS D1.1, "Structural Welding Code--Steel."
 - b) AWS D1.2, "Structural Welding Code--Aluminum."
 - c) AWS D1.3, "Structural Welding Code--Sheet Steel."
 - d) Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification. Such certification is to remain in force for the duration of the welding operations under this Contract.

C. Fabricator Qualifications: A firm experienced in producing metal fabrications similar to those

indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.

- D. Coordinate installation of anchorages for metal fabrications. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.4 PROJECT CONDITIONS:

- A. Field Measurements: Where metal fabrications are indicated to fit walls and other construction, verify dimensions by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
 - 1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating metal fabrications without field measurements. Coordinate construction to ensure that actual dimensions correspond to established dimensions. Allow for trimming and fitting.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver products undamaged.
- B. Store products so as to prevent rust.
- C. Handle products so as to prevent damage.
- D. After completion of factory testing, package and ship hatches as directed.

PART 2 - PRODUCTS

2.1 MATERIALS:

- A. General Requirements:
 - 1. Insofar as practicable, furnish similar products of a single manufacturer.
 - 2. Metal Surfaces, General: For metal fabrications exposed to view in the completed work, provide materials with smooth, flat surfaces without blemishes, Do not use materials with exposed pitting, seam marks, roller marks, rolled trade names, or roughness.

2.2 FERROUS METALS:

- A. Structural steel: Plates, shapes, bars and angles, ASTM A36.
- B. Rolled-Steel Floor plate: ASTM A786/A786M; Fabricate raised-pattern floor plates from rolled-steel floor plate, galvanized after fabrication, of thickness and in pattern indicated below:

1. Thickness: Minimum 1/4 inch, unless otherwise shown or calculated.
2. Pattern: No. 2, or as selected from manufacturer's standard patterns; flat back.
- C. High-strength low-alloy structural steel:
 1. ASTM A242.
 2. Resistance to atmospheric corrosion: Four times that of carbon steel, minimum.
- D. Load-carrier beams: ASTM A588.
- E. Structural tubing: ASTM A501.
- F. Steel Pipe: ASTM A 53, standard weight (Schedule 40), unless another weight is indicated or required by structural loads.
- G. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A666, Type 304. Type 316L for corrosive environments.
- H. Stainless-Steel Bars and Shapes: ASTM A276, Type 304. Type 316L for corrosive environments.
- I. Hot-rolled carbon steel sheets and strips: ASTM A570.
- J. Pipe, Pipe Sleeves and Pipe Fittings:
 1. Cast iron: ASTM A74, service weight.
 2. Steel: ASTM A53, galvanized unless otherwise shown or specified.
- K. Guard Chain: ASTM A413, Class Grade 28, galvanized steel, 9/32-inch thick, complete with stainless-steel eyes, spring-loaded catches and mounting components.

2.3 ALUMINUM:

- A. Aluminum Extrusions: ASTM B221, Alloy 6063
- B. Aluminum-Alloy Rolled Tread Plate: ASTM B632/B 632M, Alloy 6061.
- C. Cast Aluminum.

2.4 COATINGS:

- A. Shop Primer for Ferrous Metal: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with performance requirements in FS TT-P-664; selected for good resistance to normal atmospheric corrosion, compatibility with finish paint systems indicated, and capability to provide a sound foundation for field-applied topcoats despite prolonged exposure.
- B. Zinc-rich paint: MS MIL-P-21035.
- C. Electrodeposited zinc coating: ASTM B63
- D. Galvanizing repair compound: Stick form, melting point 600F to 650F, GALVABAR or equal.
- E. Bituminous coating: Cold-applied asphalt mastic complying with SSPC Paint 12, except containing no asbestos fibers, or cold-applied asphalt emulsion complying with ASTM D1187.

2.5 FASTENERS:

- A. General: Provide Type 304 or 316 stainless-steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B 633, Class Fe/Zn 5, where built into exterior walls. Select fasteners for type, grade, and class required.
- B. Screws: Material, type and size to suit the purpose; steel, except stainless, cadmium-plated.
 - 1. Stainless steel, ASTM A193, Alloy S30400.
- C. Machine bolts: Material, type and size best suited to the purpose. Minimum tensile strength 60,000 psi.
 - 1. Carbon steel: ASTM A307, Grade B, galvanized.
 - 2. Stainless steel: ASTM A193, Class 1A.
- D. Toggle bolt: FS FF-B-588.
- E. Drive stud: FS FF-S-325, Group 6.
- F. Expansion shield: FS FF-S-325 Group I, Type 2, Class 2, Style 1; Group II, Type 3, Class 1; Group IV, Type 1; best suited to the purpose.
- G. Screw anchors: Lead or plastic for wood or metal screws.
- H. Anchor-bolt sleeve: Corrugated high-density polyethylene plastic.

- I. Powder actuated: FS FF-P-395.
- J. Expansion Anchors: Anchor bolt and sleeve assembly of material indicated below with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and equal to four times the load imposed when installed in concrete, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.
 - 1. Material: Alloy Group 1 or 2 stainless-steel bolts complying with ASTM F593 and nuts complying with ASTM F594.
- K. Internally Threaded Steel Anchor: ASTM A108.

2.6 CONCRETE AND GROUT:

- A. Concrete Fill: Normal weight, minimum 3,000 psi structural concrete, except limit the max. coarse aggregate size to #8.
 - 1. Non-Slip aggregate: Fused aluminum oxide grits or crushed emery, factory graded and packaged, rust proof, non glazing and unaffected by
 - 2. Surface hardener: Water soluble, inorganic fluosilicate compound for curing, hardening and dustproofing fresh concrete.

2.7 FABRICATION, GENERAL:

- A. Shop Assembly: Preassemble items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.
- B. Shear and punch metals cleanly and accurately. Remove burrs.
- C. Ease exposed edges to a radius of approximately 1/32 inch, unless otherwise indicated. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- D. Weld corners and seams continuously to comply with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.

- 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- E. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.
- F. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.
- G. Fabricate joints that will be exposed to weather in a manner to exclude water, or provide weep holes where water may accumulate.
- H. Allow for thermal movement resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening up of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - 1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.
- I. Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges
- J. Remove sharp or rough areas on exposed traffic surfaces.
- K. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Use exposed fasteners of type indicated or, if not indicated, Phillips flat-head (countersunk) screws or bolts. Locate joints where least conspicuous.

2.8 LADDERS:

- A. General: Fabricate ladders for locations shown, with dimensions, spacings, details, and anchorages as indicated.
 - 1. Comply with ANSI A14.3, unless otherwise indicated.
 - 2. For elevator pit ladders, comply with ASME A17.1.
- B. Siderails: Continuous, ½-by-2-1/2-inch steel flat bars, with eased edges.
- C. Bar Rungs: 3/4-inch diameter steel bars, spaced 12 inches o.c., unless shown otherwise.
- D. Fit rungs in centerline of side rails; plug-weld and grind smooth on outer rail faces.
- E. Support each ladder at top and bottom and not more than 48 inches o.c. with welded or

bolted steel brackets. Size brackets to support design loads specified in ANSI A14.3.

- F. Provide nonslip surfaces on top of each rung by coating with abrasive material metallically bonded to rung by a proprietary process.
- G. Galvanize ladders, including brackets and fasteners, in exterior locations and in areas with corrosive environments:

2.9 LADDER SAFETY CAGES:

- A. General: Fabricate ladder safety cages to comply with ANSI A14.3. Assemble by welding or riveting.
- B. Primary Hoops: 5/16-by-4-inch steel flat bar hoops. Provide at tops and bottoms of cages and spaced not more than 20 feet o.c.
- C. Secondary Intermediate Hoops: 5/16-by-2-inch steel flat bar hoops, spaced not more than 48 inches o.c. between primary hoops.
- D. Vertical Bars: 5/16-by-2-inch steel flat bars secured to each hoop, spaced approximately 9 inches o.c.
- E. Fasten assembled safety cage to ladder rails and adjacent construction by welding or riveting, unless otherwise indicated.
- F. Galvanize ladder safety cages, including fasteners, in exterior locations and in areas with corrosive environments.

2.10 SHIP'S LADDERS:

- A. General: Design in accordance with AISC Specification for Structural Steel for Buildings-Allowable Stress Design, NAAMM Metal Stairs Manual and applicable OSHA requirements.
 - 1. Minimum live load for stairs: 100 psf.
 - 2. Stringers: At platforms and landings, extend stringers around perimeters. Close ends with continuously welded closure plates, ground smooth and flush.
- B. Provide ship's ladders where shown or indicated. Fabricate of open-type construction with structural-steel channel or steel plate stringers, steel pipe handrails, and steel bar grating treads, unless otherwise indicated. Provide brackets and fittings for installation.
- C. Treads, platforms and landings fabricated of steel plate with nonslip surface or steel grating, as shown.
- D. As far as practicable, holes for rivets, bolts and screws located in concealed positions.
- E. Galvanize ship's ladder, including fasteners, in exterior locations and in areas with corrosive environments.

2.11 SAFETY TREAD:

- A. FS RR-T-650, Type C, metallic, nonskid, class and style as shown.
- B. Drilled and countersunk to receive flathead screws.

2.12 STEEL LINTELS:

- A. Fabricated of structural steel.
- B. Multiple members riveted or welded back-to-back or separated by spacers.
- C. Shop-painted, except hot-dip galvanized after fabrication where used in exterior walls.

2.12 SHELF ANGLES:

- A. Fabricate shelf angles from steel angles of sizes indicated and for attachment to concrete framing. Provide horizontally slotted holes to receive 3/4-inch bolts, spaced not more than 6 inches from ends and 24 inches o.c., unless otherwise indicated.
- B. For cavity walls, provide vertical channel brackets to support angles from backup masonry and concrete. Align expansion joints in angles with indicated control and expansion joints in cavity-wall exterior wythe.
- C. Galvanize shelf angles to be installed in exterior walls.
- D. Furnish wedge-type concrete inserts, complete with fasteners, to attach shelf angles to cast-in-place concrete.

2.13 CORNER GUARD, CURB ANGLE AND BUMPER:

- A. Fabricated of structural steel.
- B. Shop-painted.

2.14 UNDERGROUND SAFETY WALK:

- A. Locking pin: Stainless steel, diameter to fit receptacle in hinge assembly with tolerance not greater than plus-or-minus 1/64 inch.
- B. Locking-pin chain: Fabricated of 0.128-inch diameter steel spring wire.
- C. Plug-welded in accordance with AWS D1.1.
- D. Stainless steel: ASTM A276, Alloy S20200.

- E. Bolts and washers: ASTM A325 or ASTM A490, nonrising and vibration-proof.
- F. Spring wire: ASTM A229, Class 1 or 4.
- G. Ferrous-metal components galvanized after fabrication.

2.15 AERIAL SAFETY WALK:

- A. Fabricated of floor plate, diamond pattern, flatback.
- B. Abrasive surface on plates, unless otherwise shown.
- C. Structural-steel angle frames anchored to supporting structure.
- D. Plates in sections of convenient lengths for handling and with finger holes for lifting.
- E. Galvanized after fabrication.
- F. Bolts: Stainless steel.

2.16 SCREEN AT PLATFORM BENCH:

- A. Materials:
 - 1. Base: Steel, welded.
 - 2. Bar frame: Steel, welded.
 - 3. Screen:
 - a) Wire cloth: 0.080-inch diameter steel-wire mesh, galvanized after weaving.
 - b) Frame: Steel, drilled for fasteners, holes punched for wire mesh and corners welded, galvanized.
- B. Fabrication: Insert wire cloth with wires parallel to frame members, with ends of wires through holes in frame and welded to inner surface of channel.
- C. Finish: Field-painted in accordance with Section 09920; FED STD 595, Color No. 20040.

2.17 CAST NOSING:

- A. Cast aluminum: Cross-hatched units, 4 inches wide with 1-inch lip, for casting into concrete

steps

- B. Apply bituminous paint to concealed bottoms, sides, and edges of units set into concrete.

2.18 PEDESTRIAN BARRIER:

- A. Tubing: Hot-formed square steel. Fabricated as follows:
 - 1. Heated and bent smoothly without distortion
 - 2. Joints fully welded as shown.
 - 3. Intersections coped, fully welded and ground smooth and flush.
- B. Plate: Structural steel.
- C. Floor-cover flange: Cast steel, as shown.
- D. Finish: Shop-coated and finish painted in accordance with Section 09920.

2.19 BOLLARDS:

- A. Pipe: Black Steel, ASTM A53, Type E, Grade A, Schedule 80, sized as shown, with 1/4-inch steel-plate cap welded all around and weld ground smooth
- B. Eyebolt: 1/4-inch diameter steel rod with 1/2-inch diameter eye.
- C. Concrete fill: Section 03900.
- D. Coating:
 - 1. Shop paint.
 - 2. Finish paint: Aliphatic system as specified in Section 09920.
 - 3. Hot-dip galvanize exterior bollards in accordance with ASTM A123 before bonderizing and shop priming.
- E. Chain: Guard chain, galvanized and painted to match bollard.

2.20 PARKING METER POSTS:

- A. Pipe: Black steel, ASTM A53, Type E, Grade A, Schedule 40, two-inch nominal OD.

- B. Hot-dip galvanize after cutting to length.

2.21 MISCELLANEOUS ITEMS:

- A. Fabricate metal items indicated on the drawings from materials shown or, if not otherwise described, from steel or from galvanized steel wherever exposed to the weather or in contact with concrete or masonry.
- B. Make miscellaneous items to the size and configuration indicated, welded or bolted at joints to develop full strength equal to a continuous member, and in every way complete for the intended purpose and finished in appearance.
- C. Pylon-Base Ring: Structural steel, galvanized after fabrication.
- D. Eye: ASTM A572, Grade 50, one-inch diameter steel rod, welded, galvanized after fabrication.

2.22 FINISHES:

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 1. Finish metal fabrications after assembly.
- B. Galvanizing:
 - 1. Clean ferrous metal thoroughly before applying zinc coating.
 - 2. Apply zinc coating to products after fabrication, by hot-dip method, using coating weighing not less than 2.0 ounces per square foot.
- C. Shop Paint:
 - 1. Ferrous metal thoroughly cleaned as recommended by primer manufacturer and in accordance with SSPC SP11 and, except for items to be encased in concrete, given prime coat of paint.
 - 2. Zinc yellow iron-oxide primer or red-lead base primer applied so as to thoroughly cover surfaces without leaving runs or sags.
- D. Stainless Steel: Remove tool and die marks and stretch lines or blend into finish. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.

- E. Aluminum: AA-M10 (Mechanical Finish: as fabricated, unspecified).
- F. Non-Slip Abrasive Surfaces: SLIP-NOT as manufactured by the W. S. Molnar Company or approved equal. Fabricate from steel plate or bar with abrasive material metallically bonded to steel by a proprietary process. Provide material with coefficient of friction of 0.6 or higher when tested according to ASTM C1028.

PART 3 - EXECUTION

3.1 PREPARATION:

- A. Remove foreign substances from surfaces to receive metal items.
- B. Protect surrounding surfaces from damage while performing the work of this section.

3.2 INSTALLATION, GENERAL:

- A. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal fabrications to in-place construction. Include threaded fasteners for concrete and masonry inserts, toggle bolts, through-bolts, lag bolts, wood screws, and other connectors.
- B. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
- C. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.
- D. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
- E. Field Welding: Comply with the following requirements:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no

roughness shows after finishing and contour of welded surface matches that of adjacent surface.

- F. Corrosion Protection: Coat concealed surfaces of aluminum that will come into contact with grout, concrete, masonry, wood, or dissimilar metals with a heavy coat of bituminous paint.

3.3 INSTALLING NOSINGS:

- A. Center nosings on tread widths.
- B. For nosings embedded in concrete steps or curbs, align nosings flush with riser faces and level with tread surfaces.

3.4 INSTALLING BOLLARDS: NOT USED

3.5 PAINTING AND REPAIRING COATED SURFACES:

- A. Before erection or enclosing construction, paint items that support masonry or will be concealed in finished work, except items encased in concrete.
- B. Where shop coat is abraded or burned by welding, clean and touch-up.
- C. Touch-up primed surfaces with same material as coating.
- D. Where aluminum parts come in contact with concrete or steel, coat contact surfaces of aluminum with bituminous coating.
- E. Coat field welds and repair damage to zinc-coated surfaces in accordance with ASTM A780 and as follows:
 - 1. Wire-brush areas to be coated to bright metal.
 - 2. Apply galvanizing repair compound at rate of two ounces per square foot.

* * *

END OF SECTION

SECTION 08305

ACCESS DOORS AND FRAMES

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. This section specifies providing wall and ceiling access doors and frames, fire-rated wall access doors and frames, access hatches, tile covered access hatches and passenger emergency- egress hatches.
- B. Work Specified Elsewhere:
 - 1. Cast-In-Place Concrete: Section 03900.
 - 2. Mortar, Grout and Masonry Accessories: Section 04050.
 - 3. Structural Steel: Section 05120.
 - 4. Finish Hardware: Section 08710.
 - 5. Field Painting: Section 09920.

1.2 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Product Data: For each type of door and frame indicated. Include construction details relative to materials, individual components and profiles, finishes, and fire ratings (if required) for access doors and frames.
- B. Shop Drawings: Show fabrication and installation details. Include plans, elevations, sections, hardware, fittings, fastenings, details, and attachments to other Work. Manufacturer's standard drawings may be submitted in lieu of Contractor prepared shop drawings if manufacturer's standard drawings show required details.
- C. Samples: For each door face material, at least 3 by 5 inches in size, in specified finish.

- D. Schedule: Provide complete door and frame schedule, including types, general locations, sizes, construction details, latching or locking provisions, and other data pertinent to installation.
- E. Coordination Drawings: plans drawn to scale and coordinating penetrations and ceiling-mounted items with concealed framing, suspension systems, piping, ductwork, and other construction. Show the following:
 - 1. Method of attaching door frames to surrounding construction.
 - 2. Ceiling-mounted items including access doors and frames, lighting fixtures, diffusers, grilles, speakers, sprinklers, and special trim.
- F. Certification:
 - 1. Certification from manufacturer of steel gratings verifying that gratings are capable of supporting loading as shown.
 - 2. Certified test reports of successful factory testing performed on passenger emergency-egress hatches. Certification of previous successful testing of hatches of same design furnished under similar Authority contracts acceptable in lieu of specified testing.
 - 3. Certification that welding personnel are currently qualified in accordance with AWS D1.1.

1.3 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
 - 1. Comply with codes and regulations of the jurisdictional authorities.
 - 2. AASHTO: Standard Specifications for Highway Bridges: HS-20-44 Loading.
 - 3. AGA: The Design and Fabrication of Galvanized Products.
 - 4. AISC: Specification for Structural Steel for Buildings-Allowable Stress Design
 - 5. ASTM: A36, A53, A90, A123, A143, A153, A167, A193, A276, A307, A384, A413, A501, A588, A593, A633, A666, A780, A786, B221, B633, D1187, F594.
 - 6. AWS: D1.1, D1.2, D1.3, D1.4.
 - 7. FS; FF-B-588, FF-P-395, FF-S-325, RR-G-661, TT-P-664.
 - 8. MS: MIL-P-21305.
 - 9. NAAMM: Metal Finishes Manual for Architectural Metal Products

10. NFPA: 101 (Fire Exit Hardware), 252 (Standard Method of Fire Tests for Door Assemblies)
 11. SSPC: SP 11, Paint 12.
 12. UL: 10B (Fire Tests of Door Assemblies)
- B. Source Limitations: Obtain doors and frames through one source from a single manufacturer.
- C. Fire-Rated Access Doors and Frames: Units complying with NFPA 80 that are identical to access door and frame assemblies tested for fire-test-response characteristics per the following test method and that are labeled and listed by UL, ITS, or another testing and inspecting agency acceptable to authorities having jurisdiction:
1. UL 10B for vertical access doors.
- D. Size Variations: Obtain the Engineer's acceptance of manufacturer's standard-size units, which may vary slightly from sizes indicated.
- E. Welding: Qualify procedures and personnel according to the following:
1. AWS D1.1, "Structural Welding Code—Steel."
 2. AWS D1.2, "Structural Welding Code—Aluminum."
 3. AWS D1.3, "Structural Welding Code—Sheet Steel."
 4. AWS D1.4, "Structural Welding Code—Reinforcing Steel."
 5. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification. Such certification is to remain in force for the duration of the welding operations under this Contract.

1.4 PROJECT CONDITIONS:

- A. Field Measurements: Where doors and hatches are indicated to fit in walls and other construction, verify dimensions by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

- B. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating metal fabrications without field measurements. Coordinate construction to ensure that actual dimensions correspond to established dimensions. Allow for trimming and fitting.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver products undamaged.
- B. Store products so as to prevent rust.
- C. Handle products so as to prevent damage.
- D. After completion of factory testing, package and ship hatches as directed.

1.6 COORDINATION:

- A. Verification: Determine specific locations and sizes for access doors needed to gain access to concealed equipment, and indicate on a schedule.
- B. Concrete Work: Coordinate with concrete work so that frames are available for placing integrally with floor slabs or concrete walls unless frames are to be installed during related interior floor work.

PART 2 - PRODUCTS

2.1 MATERIALS:

- A. General Requirements:
 - 1. Insofar as practicable, furnish similar products of a single manufacturer.
 - 2. Metal Surfaces, General: For metal fabrications exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, rolled trade names, or roughness.

2.2 FERROUS METALS:

- A. Structural Steel: Plates, shapes, bars and angles: ASTM A36.

2.3 FASTENERS:

- A. General: Provide Type 302 or 316 stainless steel fasteners for exterior use and zinc-plated fasteners complying with ASTM B633, Class Fe/Zn 5, where built into exterior walls. Select fasteners for type, grade, and class required.
- B. Screws: Material, type and size to suit purpose; steel, except stainless., cadmium-plated.
 - 1. Stainless steel, ASTM A193, Alloy S30400.
- C. Machine Bolts: Material, type and size best suited to the purpose. Minimum tensile strength 60,000 psi.
 - 1. Carbon steel: ASTM A307, Grade B, galvanized.
 - 2. Stainless steel: ASTM A193, Class 1A.
- D. Toggle bolt: FS FF-B-588.
- E. Drive stud: FS FF-S-325, Group 6.
- F. Expansion shield: FS FF-S-325 Group I, Type 2, Class 2, Style 1; Group II, Type 3, Class 1; Group IV, Type 1; best suited to the purpose.
- G. Screw anchors: Lead or plastic for wood or metal screws.
- H. Anchor bolt sleeve: Corrugated high-density polyethylene plastic.
- I. Powder actuated: FS FF-P-395.
- J. Expansion Anchors: Anchor bolt and sleeve assembly of material indicated below with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and equal to four times the load imposed when installed in concrete, as determined by testing per ASTM E488, conducted by a qualified independent testing agency.
 - 1. Material: Alloy Group 1 or 2 stainless steel bolts complying with ASTM F593 and nuts complying with ASTM F594.

2.4 CONCRETE AND GROUT:

- A. Nonshrink Grout: Section 04050.
- B. Surface hardener: Water-soluble, inorganic fluosilicate compound for curing, hardening and dustproofing fresh concrete.

2.5 COATINGS:

- A. Shop Primer for Ferrous Metals: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with performance requirements in FS TT-P-664; selected for good resistance to normal atmospheric corrosion, compatibility with finish paint systems indicated, and capability to provide a sound foundation for field-applied topcoats despite prolonged exposure.
- B. Galvanizing (zinc-coating by hot-dipped process): ASTM A90, ASTM A123, or ASTM A143, ASTM A153 or ASTM A384, as applicable.
- C. Zinc-rich paint: MS MIL-P-21305.
- D. Electro deposited zinc coating: ASTM B633.
- E. Galvanizing Repair Compound: Stick form, melting point 600-degree F to 650-degree F, GALVABAR or equal.
- F. Bituminous Coating: Cold-applied asphalt mastic complying with SSPC Paint 12, except containing no asbestos fibers, or cold-applied asphalt emulsion complying with ASTM D1187.

2.6 FABRICATION, GENERAL:

- A. Shop Assembly: Preassemble items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.
- B. Provide access door assemblies manufactured as integral units ready for installation.
- C. Fabricate and prepare products required to be galvanized in accordance with recommendations of AGA.
- D. Provide material that is free from mill scale, flake rust and mill pitting.
- E. Cut, reinforce, drill and tap metal fabrications as indicated to receive finish hardware, screws, and similar items. Provide plates welded on for mounting hardware.
- F. Sheer and punch metals cleanly and accurately. Remove burrs.
- G. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners whenever possible. Use exposed fasteners of type indicated or, if not indicated, Phillips flat-

head (countersunk) screws or bolts. Locate joints where least conspicuous.

- H. Ease exposed edges to a radius of approximately 1/32 inch, unless otherwise indicated. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- I. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.
- J. Where miscellaneous access openings, with exception of gratings, occur in finished floor areas, include stainless steel edge rims of depth to accommodate floor finishing materials.
- K. Welding corners and seams continuously to comply with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- L. Fabricate joints that will be exposed to weather in a manner to exclude water, or provide weep holes where water may accumulate.
- M. Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges.
- N. Remove sharp or rough areas on exposed traffic surfaces.
- O. Painting: Shop paint (prime) before shipment. Phosphatize galvanized surfaces before priming.

2.7 WALL ACCESS DOORS AND FRAMES:

- A. Access Doors: Steel, baked-enamel prime coat; 12-inches square, minimum size.
 - 1. Wall-mounted, hollow metal type: Size over four square feet.
 - a) Door and frame: Conform to the requirements of Section 08110; galvanized in

exterior walls.

- b) Hardware: Equipped with spring hinges and lockset conforming to requirements of Section 08710; locks keyed into group with mechanical rooms.
- c) Fire rated: UL 1-1/2 hour B-Label, with labeled hardware.

2.8 FINISHES:

A. General:

- 1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- 2. Finish metal fabrications after assembly.
- 3. Galvanize ferrous metal unless other finish is shown or specified.

B. Galvanizing:

- 1. Clean ferrous metal thoroughly before applying zinc coating.
- 2. Apply zinc coating to products after fabrication, by hot-dip method, using coating weighing not less than two ounces per-square-foot.

C. Shop Paint:

- 1. Ferrous metal thoroughly cleaned as recommended by primer manufacturer and in accordance with SSPC SP11 and, except for items to be encased in concrete, given prime coat of paint.
- 2. Zinc yellow iron-oxide primer or red-lead based primer applied so as to thoroughly cover surfaces without leaving runs or sags.

PART 3 - EXECUTION

3.1 PREPARATION:

- A. Advise installers of other work about specific requirements relating to access door and floor door installation, including sizes of openings to receive access door and frame, as well as locations of supports, inserts, and anchoring devices.
- B. Examine the substrates and conditions under which the work is to be performed, and notify the General Contractor in writing of conditions detrimental to the proper and timely completion of the

work. Do not proceed with the installation until unsatisfactory conditions have been corrected.

- C. Remove foreign substances from surfaces to receive metal items.
- D. Protect surrounding surfaces from damage while performing the work of this section.

3.2 INSTALLATION, GENERAL:

- A. Coordinate placement of doors with the work of other trades.
- B. Comply with manufacturer's written instructions for installing all access doors and hatches.
- C. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal fabrications to in-place construction. Include threaded fasteners for concrete and masonry inserts, toggle bolts, through-bolts, lag bolts, wood screws, and other connectors.
- D. Cutting, Fitting and Placement: Perform cutting, drilling, and fitting required for installing doors and hatches. Set frames, doors and hatches accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
- E. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry or similar construction.
- F. Provide anchors and inserts in sufficient numbers for proper fastening of doors and hatches.
- G. Provide bar anchors with turned ends extending six inches minimum into concrete and 12 inches minimum into masonry. Lay anchors flat in masonry joints.
- H. Embed anchors accurately in concrete to permit aligning door in proper position.
- I. For fabricated items, use fastenings and anchors of size and type shown on approved shop drawings or manufacturer's standard drawings.

3.3 PAINTING AND REPAIRING COATED SURFACES:

- A. Before erection or enclosing construction, paint items that support masonry or will be concealed in finish work, except items encased in concrete.
- B. Where shop coat is abraded or burned by welding, clean and touch-up.
- C. Touch-up primed surfaces with same material as coating.
- D. Where aluminum parts come in contact with concrete or steel, coat contact surfaces of aluminum with bituminous coating.
- E. Coat field welds and repair damage to zinc-coated surfaces in accordance with ASTM A780 and as follows:

1. Wire brush areas to be coated to bright metal.
2. Apply galvanizing repair compound at rate of two ounces per-square-foot.

3.4 ADJUSTING AND CLEANING:

- A. Adjust doors and hardware after installation for proper operation.
- B. Remove and replace doors and frames that are warped, bowed, or otherwise damaged.

* * *

END OF SECTION

SECTION 08710

FINISH HARDWARE

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. This section specifies providing finish hardware.
- B. Related Work Specified Elsewhere:
 - 1. Access Doors and Frames including locks and cylinders: Section 08305.

1.2 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
 - 1. Comply with codes and regulation of the jurisdictional authorities.
 - 2. ANSI/BHMA: A156-Series Standards for Builders Hardware.
 - 3. ASTM: A413
 - 4. FS: TT-S-001657.
 - 5. ADA: ADAAG.
 - 6. NFPA: 80, 101, 130.
 - 7. DHI: Recommended Locations for Builders Hardware for Standard Steel Doors and Frames, Recommended Locations for Builders Hardware for Custom Steel Doors and Frames.
- B. Hardware Supplier Qualifications: A recognized architectural finish hardware supplier, with warehousing facilities in the Project's vicinity, that has a record of successful in-service performance for supplying finish hardware similar in quantity, type, and quality to that indicated for this Project and that employs an experienced architectural hardware consultant (AHC) who is available to the Engineer and Contractor, at reasonable times during the course of the Work for consultation.
 - 1. Require supplier to have his AHC develop the hardware schedule.
 - 2. Require supplier's AHC to meet with the Engineer to discuss and finalize lock-functions and keying requirements.
- C. Fire-Rated Openings: Provide hardware for fire-rated openings that complies with NFPA 80 and

requirements of authorities having jurisdiction. Provide only items of hardware that are listed and are identical to products tested by UL, Warnock Hersey, FM, or other testing and inspecting organization acceptable to authorities having jurisdiction for use on types and sizes of doors indicated in compliance with requirements of fire-rated door and door frame labels.

1. Equip labeled doors with hinges of steel or stainless steel base metal, closers, and automatic latching devices in addition to the hardware requirements in the specified hardware sets.
2. If a conflict appears between this paragraph and the hardware sets scheduled, the requirements of this paragraph govern.

D. Americans With Disabilities Act (ADA): Comply with the ADA Accessibility Guidelines (ADAAG).

1.3 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

A. Shop Drawings:

1. Product Data: Manufacturers' technical literature and catalog cuts, edited as necessary to indicate each item of hardware, model, selected options, finish, installation instructions, maintenance of operating parts and finish, and other information necessary to show compliance with requirements. Make coordinated submittals packages complete with all supporting data.
2. Hardware Schedule: Hardware schedule coordinated with doors, frames, gates and related work to ensure proper size, thickness, hand, function, design and finish of hardware. Base Hardware Schedule on hardware sets indicated in PART 3 of this section. Indicate complete designations of each item required for each door or opening, including the following information:
 - a) Explanation of each abbreviation, symbol, and code contained in hardware schedule. Schedules with unidentified notations will be rejected without review.
 - b) Door and frame number, size, and materials.
 - c) Type, style, function, size, and finish of each hardware item. Include lockset functions, angle of closer operation, lever and handle designs, lengths of flush bolts, types of stops, sizes of armor and kick plates, and other such data.

- d) Name and manufacturer of each item.
 - e) Fastenings and other pertinent information.
 - f) Location of each hardware set cross-referenced to indications on Drawings, both on floor plans and in door schedule.
 - g) Mounting locations for hardware.
 - h) Keying information.
- 3. Submittal sequence: Submit hardware schedule at earliest possible date particularly where acceptance of hardware schedule must precede fabrication of other work that is critical in the Project construction schedule. Include with hardware schedule the product data, samples, shop drawings of work affected by finish hardware, and other information essential to a coordinated review of hardware schedule.
 - 4. Templates: Transmit hardware templates directly to trades fabricating related work specified to be prepared for the installation of finish hardware under this section. Submit record copy of these transmittals to the AR.
 - 5. Coordinating hardware preparation by other trades: Check shop drawings of other trades to ensure that correct provisions from transmitted templates are made for locating and installing finish hardware to comply with indicated requirements.

B. Samples:

- 1. Finishes: Two, minimum four-inch squares of each finish to be furnished. Submit with shop drawings.
- 2. Hardware units: Each type of exposed hardware unit in approved finish and tagged with full description for coordination with hardware schedule. Submit unit samples prior to submission of final hardware schedule.
 - a) When requested, samples will be returned to the supplier. Accepted units that remain undamaged through the submittal, review, and field-comparison process may, after final check of operation, be used in the Work, within limitations of keying coordination requirements.
 - b) Submit the following:
 - (1) One sample of a lockset including, trim, escutcheon, strike box, lever,

cylinder, and key.

- (2) One sample of hinge.
- (3) One sample of each miscellaneous item of finish hardware.
- (4) Provide finishes so that color and surface finish or polish of various items of the same designated finish match throughout the work. Hardware with non-matching finishes will be rejected.

- c) The Authority reserves the right to require samples of each specific item to be furnished.

C. Certification.

D. Documentation:

- 1. Construction keying schedule.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver products to jobsite in original unopened packages, clearly labeled with manufacturer's name, brand, specification identification data and identification as shown on approved hardware schedule.
- B. Store products in an approved dry area, protect from contact with soil and from exposure to the elements. Keep products dry.
- C. Handle products so as to prevent breakage of containers and damage to products.

1.5 MAINTENANCE TOOLS AND INSTRUCTIONS:

- A. Furnish a complete set of specialized tools and maintenance instructions as needed for the Authority's continued adjustment, maintenance, removal and replacement of hardware.

PART 2 - PRODUCTS

2.1 HARDWARE TYPES:

A. General:

- 1. Hardware grade: Provide only Grade 1 hardware in accordance with

ANSI/BHMA A156-Series Standards and with the additional requirements specified in this section, except where otherwise specified or approved in writing by the Engineer for each specific door number.

2. Fire-rated hardware: Where applied to fire-rated labeled doors and frames, provide fire-rated listed hardware, tested by a fire-rating testing agency acceptable to authorities having jurisdiction.
 3. Finishes: Finish designations are ANSI/BHMA A156.18 standards and are subject to approval for color, texture and appearance.
 - a) Finish 630 (Formerly US 32D): Except where otherwise indicated, provide finish 630, satin-polish stainless steel on stainless steel base metal, matching sample on file with the Engineer.
 - b) Finish 626 (Formerly US 26D): Where indicated, provide finish 626, satin-polish chromium plated over nickel on brass or bronze base metal, matching finish 630 as specified above.
 - c) Finish 628 (Formerly US 28): Where indicated, provide finish 628, satin-polish aluminum clear anodized over aluminum base metal.
 - d) Finish 652 (Formerly US 26D): Where indicated, provide finish 652, satin-polish chromium plated over nickel on steel base metal, matching finish 630 as specified above.
 - e) Finish 719 (Formerly US27): Mill finish aluminum uncoated.
 - f) Finish 613 (Formerly US10B): Where indicated, provide finish 613, satin-finish statuary bronze.
 - g) Finish 630 may be substituted for Finish 626 or Finish 652 at no additional cost to the Authority.
 4. Single Source: Obtain each type of hardware from a single manufacturer.
- B. Hinges: ANSI/BHMA A156.1, full mortise butt hinges, anti-friction bearings, button tips (not flush), unless otherwise specified for each specific door number. Extruded butts may be used in lieu of wrought butts.
1. Quantity required per door leaf:
 - a) Doors 61 inches to 90 inches in height: 1-1/2 pairs.

- b) Doors 91 inches to 120 inches in height: Two pairs.

2. Types:

- a) Exterior doors, doors from public passageways, and doors to wet areas such as showers: Stainless steel butts, Type A5111, finish 630.
- b) Interior, non-public doors: Steel butts, Type A8111 (Grade 1), Finish 652.
- c) Doors with reverse-bevel swing (out-swinging) having locks: Fit butts with non-removable pins effective when door is in closed position.

C. Locksets:

- D. Hollow metal doors: ANSI/BHMA A156.13, full mortise, adjustable armored front, 3/4-inch-throw anti-friction latchbolt, one-inch-throw stainless steel deadbolt, Finish 630, Function as scheduled.

1. Trim design:

- a) Cast lever handles, recurving to within ½-inch of door face, equal in appearance and dimensions to one of the following unless otherwise scheduled:

Series	Design	Producer
ML2200 Series	Newport NSA	Corbin/Russwin
8200 Series	KD rose, L lever	Sargent
8700 Series	PB lever, YK rose	Yale

- b) Finish: 630 unless otherwise scheduled.
- c) Roses: Concealed screw or screwless, 2-1/4 inch diameter.
- d) Cylinder trim: Equip with flush or security-beveled solid cylinder collar as appropriate for flush or projecting cylinder.

2. Aluminum doors in Yard Buildings:

- a) Finish: 630 unless otherwise scheduled.

- E. Cylinders and Keying for all doors except aluminum doors in Parking Structures: Match the Authority's existing keying and interchangeable core system as follows and at no additional cost to the Authority.

1. Cylinders: Finish 630.
 - a) For locksets: ANSI/BHMA A156.5, interchangeable-core type, designed to accept the Authority's existing Russwin Recore System. One core furnished for each lock, stamped with visual key control.
 - b) High security: Interlocking-pin type, Emhart High-Security Locking System or equal.
 - c) Construction cores: Provide construction cylinders until final cylinders and keying is approved and installed.
 2. Keys and keying:
 - a) Keys: Stamped with the inscription TRANSIT AUTHORITY - DO NOT DUPLICATE and with visual key-control data.
 - b) Quantity: Three keys for each core plus blanks equal to 10-percent of total keys furnished.
 3. Key tags and holders: ANSI/BHMA A156.5, inscribed with key-change number and key-control symbol.
- F. Push Plates and Door Pulls: ANSI/BHMA A156.6, Finish 630, with the following additional requirements:
1. Push plate: 3/16 inch by 10 inches by 20 inches unless otherwise shown, with edges beveled.
 2. Door pull: 3/4-inch round bar, eight inches center-to-center, concealed fasteners; escutcheon plate same as push plate.
- G. Door Closers: ANSI/BHMA A156.4, Type C02xx1 (xx - indicates top-of-door-mounted, on interior side), Finish 630.
1. Surface-mounted.
 2. Sweep period: Adjusted so that from an open position of 70 degrees, the door will take at least three seconds to move to a point 3 inches from the latch, measured to the leading edge of the door.
 3. Cover plate: Full metal cover, Finish 630.

4. Parallel arms and drop brackets: Provide as necessary for mounting on interior side unless otherwise noted. Where hold-open feature is specified for closers, use type that permits doors to open 140 degrees, other conditions permitting.
5. Maximum force for pushing or pulling open a door with closer (measured with a push-pull scale applied perpendicular to the door at the door opener or 30 inches from the hinged side, whichever is farther from the hinge):

a) Fire doors: Minimum opening force allowable by the jurisdictional authorities. b)

Interior hinged doors: 5 lbf.

H. Stops:

1. Overhead-type: ANSI/BHMA A156.8, Type C54511 holder/stop; holder deactivated on labeled doors, Finish 630.
2. Wall-type: ANSI/BHMA A156.16, Type L02101, with vandal-resistant concealed fasteners, Finish 630. Use floor-type where wall-type is not practicable.
3. Floor-type: ANSI/BHMA A156.16, Type L02141 or L02161 as necessary, with matching extender if necessary to properly engage door bottom, Finish 630.

I. Flush Extension Bolts: ANSI/BHMA A156.8, Type L04081, Finish 630.

1. Dustproof strikes, Type L04021, provided for bolts located at bottom of door leaf, except where metal thresholds are specified. Cut opening to suit bolt.
2. Operating mechanism located approximately six feet from floor for top bolts and approximately 12 inches from floor for bottom bolts.
3. Bolts located in edge of inactive leaf of pair of doors.
4. Automatic Flush Bolts: Listed for 1-1/2 hour, B-labeled, Finish 630; Ives No. 559 or equal with strikes; with coordinator where recommended by manufacturer.

J. Silencers: ANSI/BHMA A156.16, Type L03011. Provide silencers for each door:

1. Three for each single door.
2. Two for each pair of doors.

K. Exit Devices: ANSI/BHMA A156.3; complying with NFPA 80, listed and labeled by a testing and

inspecting agency acceptable to authorities having jurisdiction; lever trim as required for locksets; Finish 630.

1. Single door: Function F03 (mortise); latch bolt by push on crossbar inside and by key from outside; operation from outside is by lever.
 2. Double door: Active leaf Function F03 as above, inactive leaf (manual flush bolts) without outside trim.
 3. Maximum pushing force to operate exit device:
 - a) Fire doors: Minimum opening force allowable by the jurisdictional authorities.
 - b) Interior hinged doors: 5 lbf.
 4. Coordinators: ANSI/BHMA A156.3.
- L. Metal Thresholds: ANSI/BHMA A156.21; profiles as shown for each location; ADA compliant; metal thickness 0.125 inch; maximum height 5/16"; with countersunk matching screws.
1. Public passageways and mezzanines: Finish 630, stainless steel with abrasive finish or Finish 613, satin-finish statuary bronze.
 2. Other locations: Finish 719, mill finish aluminum with grooves.
- M. Weather Stripping /Smoke Seals: ANSI/BHMA A156.22, Finish 628 (satin aluminum clear anodized) with stainless steel sheet-metal screws and as follows:
1. Head and jamb: Head and jamb type, stop-applied; National Guard A626 or equal. Provide nylon brush gasketing or equal.
 2. Sill: Drip strip at sill; National Guard 15 or equal.
 3. Sweep: Door sweep type, surface mounted at bottom of door; National Guard D608 nylon brush gasketing or equal. Provide sweep in addition to drip strip where scheduled.
 4. Astragals: Provide nylon brush overlapping type: National Guard 600 or equal.
- N. Chain: ASTM A413, Class PT, case-hardened, carbon-steel security chain, 3/8-inch diameter.
- O. Padlock: Interchangeable-core type padlock, designed to accept the Authority's existing Russwin Recore System.
1. One core furnished for each lock, stamped with visual key control; with two keys,

keyed and master-keyed as directed.

2. Body: Solid extruded brass.

3. Five-pin tumblers.

4. Shackle: Hardened steel, zinc-plated, 1-3/4 inch opening height, self-locking spring- type.

P. Deadlock: ANSI/BHMA A156.5 mortise dead lock, Grade 2 (½-inch minimum throw) with interchangeable-core cylinder; operation as scheduled.

Q. Authority-Furnished Property:

1. Cross-bar lock: High-security locking bar with surface-mounted keepers, inside knob and high-security cylinder.

2.2 FASTENINGS:

A. Provide hardware complete with screws, through-bolts and other fasteners of suitable type for secure anchorage to construction materials.

B. Screws, through-bolts and other fasteners having spanner-type heads: As approved.

C. Provide fasteners that harmonize in material, color and texture with finished appearance of hardware items.

D. Provide concealed fastenings with door pull, flush pulls, wall door stops and other such items.

E. Provide spanner-head through-bolts and hex bolts as applicable for surface-mounted hardware.

F. Sheet-metal screws and self-tapping screws are prohibited except where specified.

2.3 TEMPLATES:

A. Furnish templates of hardware to other trades, so that doors, frames and gates can be cut, reinforced and otherwise prepared in the shop for installation of finish hardware.

2.4 THRESHOLD SEALANT:

A. Butyl: Polymerized butyl rubber and inert fillers (pigments), solvent-based with minimum 75 percent solids, non-sag consistency, tack-free time of 24 hours or less, paintable, non-staining,

and complying with FS TT-S-001657.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. General:

1. Coordinate work of this section with work of other trades.
2. Install each hardware item in compliance with the manufacturer's instructions and recommendations.
3. Apply finish hardware in a neat and workmanlike manner. Set units level, plumb, and true to line and location. Adjust and reinforce the attachment substrate as necessary for proper installation and operation.
4. Cut mortises neat, clean and of proper net size. Drill and countersink units that are not factory prepared for anchorage fasteners. Space fasteners and anchors in accordance with industry standards.
5. Where cutting and fitting is required to install hardware onto or into surfaces that are later to be painted or finished in another way, coordinate removal, storage, and reinstallation or application of surface protection with finishing work specified in other sections. Do not install surface-mounted items until finishes have been completed on the substrates involved.
6. Provide keying in accordance with keying schedule prepared by and for the Contractor in accordance with the Authority's keying system. Deliver keying schedule and keys to the Engineer prior to final acceptance.

B. Mounting Heights: Mount hardware units at heights indicated in the following publications, except as specifically indicated or required to comply with governing regulations and except as otherwise directed by the Engineer:

1. Recommended Locations for Builders Hardware for Standard Steel Doors and Frames by DHI.
2. Recommended Locations for Builders Hardware for Custom Steel Doors and Frames by DHI.
3. ADA Accessibility Guidelines (ADAAG).

- C. Exterior Thresholds: Set thresholds for exterior doors in full bed of specified butyl sealant.
- D. Weatherstripping /Smoke Seals: Install weatherstripping around entire perimeter of door frame to form a complete seal and in accordance with manufacturers instructions.
 - 1. Position and install head and jamb weatherstripping so that door closes snugly against seal but does not inhibit latching of lockset.
 - 2. Position and install sill weatherstripping to seal snugly against threshold without inhibiting latching of lockset.
 - 3. Note that at fire-rated doors, lockset is to latch by closer operation only, without manual assistance.
- E. Adjustment: Adjust hardware to operate as designed and replace hardware that is missing, scratched, marred or otherwise damaged.
 - 1. Adjust and check each operating item of hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate freely and smoothly or as intended for the application made.
 - 2. Where door hardware is installed more than one month prior to acceptance or occupancy of a space or area, return to the installation during the week prior to acceptance or occupancy and make final check and adjustment of hardware items in such space or area. Clean operating items as necessary to restore proper function and finish of hardware and doors. Adjust door control devices to compensate for final operation of heating and ventilating equipment.
 - 3. Clean adjacent surfaces soiled by hardware installation.
- F. Instruction: At a time prescribed by the AR, have the hardware installer or knowledgeable operating-hardware-manufacturers' representatives instruct the Authority's personnel in the proper adjustment and maintenance of hardware and hardware finishes.

3.2 CLEAN-UP:

- A. Remove from the site rubbish and debris caused by this work.
- B. Leave areas surrounding doors in broom-clean condition.

* * *

END OF SECTION

SECTION 09920

FIELD PAINTING

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. This section specifies furnishing and applying paint at the site.
 - 1. Specific surfaces and areas which require field painting and required paint systems are listed in the schedule of painting.
 - 2. Unless an item is shown not to be field painted or specified otherwise, paint it in accordance with these specifications.
- B. Definitions:
 - 1. Paint: Includes primers and undercoaters, sealers, stains, paint, varnish, enamel, epoxy and special coatings.
- C. Items Not Included In Field Painting:
 - 1. Stainless steel, ornamental metals, glass, resilient tile, ceramic tile, paving, acoustical tile, plastic laminate and similar items which are prefinished.
 - 2. Mill-, factory- and shop-applied primers and finishes.
 - 3. Corrosion-resistant structural steel, ASTM A242.
 - 4. High-strength structural corrosion-resistant steel shapes, plates and bars, ASTM A588.
 - 5. Galvanized-metal surfaces except fire stand pipes, unless exposed to public view.
 - 6. UL labels on fire-rated doors and frames.
 - 7. Precast or prestressed concrete with a sandblast finish, concrete sealer, or other special finish unless noted otherwise.
- D. Related Work Specified Elsewhere:
 - 1. Mill-, factory- and shop-applied prime and finish coats: Specified with the product.

1.2 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the

additional requirements as specified for each:

A. Samples:

1. Three each of each color and texture, with identification of materials keyed to those specified and application methods.
2. Samples of paint scheduled for application to smooth finishes applied to 12-inch square hardboard or metal panels.
3. Samples of paint scheduled for application to concrete masonry units applied to 16-inch square by two-inch thick panel of concrete masonry units, including one tooled masonry joint. Subdivide panel to define prime or filler, intermediate and finish coats.

1.3 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of the jurisdictional authorities.
2. FS: TT-E-489, TT-E-490, TT-E-509, TT-F-336, TT-F-1098, TT-P-19, TT-P-29, TT-P-636, TT-P-641, TT-P-645, TT-P-650, TT-P-664, TT-P-1510, TT-P-001984, TT-S-71, TT-S-300, TT-V-86, TT-V-119.
3. ASME: A13.1.
4. ANSI: Z535.1.
5. ASTM: A242, A588, B117, C476, C920.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver products to the jobsite in their original unopened containers clearly labeled with the manufacturer's name and brand designation, referenced specification number and type, as applicable.
- B. Store products in an approved ventilated dry area, protect from contact with soil and from exposure to the elements. Always keep products dry. Do not allow paint to freeze.
- C. Handle products in a manner that will prevent breakage of containers and damage to products.

1.5 JOB CONDITIONS:

A. Environmental Requirements:

1. Do not apply paint to non-protected surfaces in wet weather or to surfaces on which ice, frost, water or dampness is visible.
2. Do not apply exterior paint when the temperature is below 40F or expected to fall below this temperature. Do not apply interior paint when the temperature is lower than 60F or expected to fall below this temperature.
3. Avoid painting steel which is at a temperature which can cause blistering, porosity, or otherwise be detrimental to the life of the paint. When paint is applied in hot weather or thinned in cold weather ensure that the specified thickness of paint coating is obtained.
4. Do not apply paint in rain, wind, snow, fog or mist or when the steel surface temperature is below the dew point, resulting in condensation of moisture.
5. Do not apply interior paint when, in the Engineer's opinion, satisfactory results cannot be obtained due to high humidity and excessive temperature; however, failure of the Engineer to notify the Contractor of the conditions will not relieve the Contractor of responsibility to produce satisfactory results.

PART 2 - PRODUCTS

2.1 GENERAL:

- A. To the maximum extent practicable, use the materials of one manufacturer throughout the project. No claims as to the suitability of a material specified, or of inability to produce first-class work with these materials, will be considered unless such claims are made in writing and submitted with the Contractor's Bid Proposal.
- B. Provide a primer suitable for each substrate type and which is manufactured or recommended by the paint manufacturer as part of a complete painting system.
- C. Previously Primed Surfaces:
 1. If surfaces have been primed off-site at the mill, factory or shop, omit specified primer, but only if the off-site primer is acceptable to the paint system manufacturer for best performance of the specified paint system.
 2. For touch-up of off-site primer, use primer of the same composition as the mill,

factory or shop primer.

- D. VOC Requirements: Provide products in compliance with local volatile organic compound regulations. If the listed product of a manufacturer does not comply, provide an accepted equivalent product which does comply.
- E. Colors:
 - 1. Prior to beginning work, the Contractor will be furnished sample color chips and a Color and Material Schedule for surfaces to be painted.
 - 2. Match the colors of the chips and submit samples before proceeding. Label samples for surface finishes such as satin, flat or gloss as listed in the Color and Material Schedule.
 - 3. Tint each coat of paint slightly lighter or darker than the preceding coat or the finish coat.
 - 4. Final approval of colors will be made by the Engineer on samples applied on the job.
 - 5. Safety Colors: Items specified to be safety colors, e.g. OSHA red (safety red) and ANSI orange, to be in compliance with ANSI Z535.1, Safety Color Code.
- F. Listed materials are a guide to quality intended. Substitute materials and paint systems acceptable to the Engineer, as an equal or of superior quality for each intended use, may be used in the work at no additional cost to the Authority.
- G. Accessory Materials:
 - 1. General: Provide miscellaneous materials and accessories, whether listed or not, as Necessary to complete the work in an approved manner.
 - 2. Caulk: Single-component, chemically curing, synthetic rubber, non-sag, ASTM C920, Type S, NS, Class 25.
 - 3. Spackling compound: Ready-mixed type, U.S. Gypsum Ready-Mixed Joint Compound - Topping, ASTM C476 or equal.
 - 4. Thinner: As recommended by the paint manufacturer.

2.2 EXTERIOR PAINTING SYSTEMS:

- A. Exterior Paint Schedule: Provide the paint systems scheduled below for the various substrates, as indicated. Provide a complete paint system by one manufacturer for each

substrate. Unless otherwise indicated, provide the following:

- B. 1. Concrete and masonry (except concrete masonry units): Acrylic, flat.
- 2. Concrete masonry units: Acrylic, flat.
- 3. Portland cement plaster (soffits): Acrylic, flat.
- 4. Ferrous metal: Silicone-alkyd, semigloss.
- 5. Zinc-coated metal: Silicone-alkyd, semigloss.
- 6. Aluminum: Alkyd, semigloss.
- 7. Wood: Acrylic-enamel, semigloss.
- 8. Mechanical and electrical items (not finish painted): See substrate materials above.
- C. Concrete, Masonry (except concrete masonry units), and portland cement plaster - Acrylic, Flat: Two coats with total dry film thickness not less than 2.5 mils.
 - 1. Undercoat: Quick-drying, flat, acrylic paint for use on the exterior over concrete, masonry, and portland cement plaster (FS TT-P-19):
 - a) Con-Lux: Mason-Plex 800 Series.
 - b) S-W: Silicone Alkyd Enamel B-56 Series.
 - c) Tnemec: Series 23 Enduratone.
 - 2. S-W:A-100 Acrylic Latex Flat Exterior Finish, A-6 Series.Finish Coat: Quick-drying, flat, acrylic paint for use on the exterior over concrete, masonry, and portland cement plaster (FS TT-P-19)
 - a) Con-Lux: Mason-Plex 800 Series.
 - b) Devoe: 15XX Wonder-Shield Exterior Acrylic Latex Flat House Paint.
 - c) Moore: Moore's Flat Exterior Latex Masonry & House Paint #105.
 - d) S-W: A-100 Acrylic Latex Flat Exterior Finish, A-6 Series.
 - 3. Finish Coat: Silicone-alkyd enamel with a minimum of 30% silicon contents meeting the qualitative requirements of FS TT-E-490:
 - a) Con-Lux: Steel-Master 9500 Series.
 - b) S-W:Silicone Alkyd Enamel B-56 series.

c) Tnemec: Series 82 Silicone-Alkyd Enamel.

D. Concrete Masonry Units - Acrylic, Flat: Two coats over block filler with total dry film thickness not less than 2.5 mils, excluding the block filler.

1. Block Filler: High performance latex block filler used for filling open textured concrete masonry block before application of top coats:

- a) Con-Lux: Block-Plex 85 White.
- b) Devoe: 52901 Bloxfil Acrylic Latex Block Filler.
- c) Moore: Moorcraft Block Filler #145.
- d) S-W: Heavy-Duty Block Filler B42W46.

2. Undercoat: Quick-drying, flat, acrylic paint for use on the exterior over concrete masonry block (FS TT-P-19):

- a) Con-Lux: Mason-Plex 800 Series.
- b) Devoe: 15XX Wonder-Shield Exterior Acrylic Latex Flat House Paint.
- c) Moore: Moore's Flat Exterior Latex Masonry & House Paint #105.
- d) S-W: A-100 Acrylic Latex Flat Exterior Finish, A-6 Series.

3. Finish Coat: Quick-drying, flat, acrylic paint for use on the exterior over concrete masonry block (FS TT-P-19):

- a) Con-Lux: Mason-Plex 800 Series.
- b) Devoe: 15XX Wonder-Shield Exterior Acrylic Latex Flat House Paint.
- c) Moore: Moore's Flat Exterior Latex Masonry & House Paint #105.
- d) S-W: A-100 Acrylic Latex Flat Exterior Finish, A-6 Series

E. Ferrous Metal - Silicone-Alkyd, Semigloss: Two coats over primer.(Apply a second coat of primer on steel which is at grade, at slab, or passing through floor slabs. Apply to a uniform line six inches above top of grade or slab.)

1. Primer: Lead and chromate-free high solids primer which chemically inhibits rusting and is recommended by the manufacturer for application to steel which has been prepared in accordance with SSPC SP2. Rated 10 (less than 0.01% surface rusting) when tested in accordance with ASTM B117 for 500 hours. Exceeds performance requirements of FS TT-P-636:
 - a) Con-Lux: Rust Arrestor 50.
 - b) S-W: Kem Kromik Universal Metal Primer B50NZ6.
 - c) Tnemec: Series P10.
 2. Undercoat: Alkyd enamel recommended by manufacturer of finish coat as an intermediate coat over specified primer for application of silicone-alkyd finish coat:
 - a) Con-Lux: FerroX Primer.
 - b) S-W: Silicone Alkyd Enamel B-56 Series.
 - c) Tnemec: Series 23 Enduratone.
 3. Finish Coat: Silicone-alkyd enamel with a minimum of 30% silicone content meeting the qualitative requirements of FS TT-E-490:
 - a) Con-Lux: Steel-Master 9500 Series.
 - b) S-W: Silicone Alkyd Enamel B-56 Series.
 - c) Tnemec: Series 82 Silicone-Alkyd Enamel.
- F Ferrus Metal - Alkyd, Semigloss: Two coats over primer (primer is not required on shop-primed
1. Primer: Quick-drying, rust-inhibiting primer for priming ferrous metal under alkyd enamel (FS TT-P-664):
 - a) Con-Lux: FerroX Primer, 25 Red.
 - b) Devoe: 41820 Bar-Ox Alkyd Shop/Field Primer.
 - c) Moore: Ironclad Retardo Rust-Inhibitive Paint #163.
 - d) S-W: Kem Kromik Metal Primer B50N2/B50W1.
 2. Undercoat: Weather-resistant, air-drying, semigloss alkyd enamel for use on the exterior over prime-coated ferrous metal (FS TT-E-489, Class A):
 - a) Con-Lux: Enamelite Semi-Luster Series
 - b) Devoe: 70XX Mirrolac Interior/Exterior Alkyd Enamel.
 - c) Moore: Impervo Enamel #133.
 - d) S-W: Industrial Enamel, B-54Z Series.

3. Finish Coat: Weather-resistant, air-drying, semigloss alkyd enamel for use on the exterior over prime-coated ferrous metal (FS TT-E-489, Class A):

- a) Con-Lux: Enamelite Semi-Luster Series.
- b) Devoe: 70XX Mirrolac Interior/Exterior Alkyd Enamel.
- c) Moore: Impervo Enamel #133.
- d) S-W: Industrial Enamel, B-54Z Series.

G. Zinc-Coated Metal - Silicone-Alkyd, Semigloss: Two coats over factory-applied primer:

1. Primer: Galvanized metal primer used to prime zinc-coated (galvanized) metal surfaces (FS TT-P-641), or one of the following.

- a) Con-Lux: Bond-Plex 46 Barrier Green.
- b) Devoe: 13201 Mirrolac Galvanized Metal Primer.
- c) Moore: Ironclad Galvanized Metal Latex Primer #155.
- d) S-W: Industrial Water Based Acrylic Paint B42W110.

2. Undercoat: Alkyd enamel recommended by manufacturer of finish coat as an intermediate coat over factory-applied primer for application of silicone-alkyd finish coat:

- a) Con-Lux: FerroX Primer.
- b) S-W: Silicone Alkyd Enamel B-56 Series.
- c) Tnemec: Series 23 Enduratone.

3. Finish Coat: Silicone-alkyd enamel with a minimum of 30% silicone content meeting the qualitative requirements of FS TT-E-490:

- a) Con-Lux: Steel-Master 9500 Series.
- b) S-W: Silicone Alkyd Enamel B-56 Series.
- c) Tnemec: Series 82 Silicone-Alkyd Enamel.

H. Zinc-Coated Metal - Alkyd, Semigloss: Two coats over primer:

1. Primer: Galvanized metal primer used to prime zinc-coated (galvanized) metal surfaces

(FS TT-P-641), or one of the following:

- a) Con-Lux: Bond-Plex 46 Barrier Green.
 - b) Devoe: 13201 Mirrolac Galvanized Metal Primer.
 - c) Moore: Ironclad Galvanized Metal Latex Primer #155.
 - d) S-W: Industrial Water Based Acrylic Paint B42W110.
2. Undercoat: Weather-resistant, air-drying, semigloss alkyd enamel for use on the exterior over prime-coated zinc-coated (galvanized) metal (FS TT-E-489, Class A):
- a) Con-Lux: Enamelite Semi-Luster Series.
 - b) Devoe: 70XX Mirrolac Interior/Exterior Alkyd Enamel.
 - c) Moore: Impervo Enamel #133.
 - d) S-W: Industrial Enamel, B-54Z Series.
3. Finish Coat: Weather-resistant, air-drying, semigloss alkyd enamel for use on the exterior over prime-coated zinc-coated (galvanized) metal (FS TT-E-489, Class A):
- a) Con-Lux: Enamelite Semi-Luster Series.
 - b) Devoe: 70XX Mirrolac Interior/Exterior Alkyd Enamel.
 - c) Moore: Impervo Enamel #133.
 - d) S-W: Industrial Enamel, B-54Z Series H. Aluminum - Alkyd,
- Semigloss: Two coats over primer:
1. Primer: Alkyd-type zinc chromate primer used for priming aluminum under alkyd enamels (FS TT-P-645), or one of the following.
- a) Con-Lux: Bond-Plex 46 Barrier Green.

- b) Devoe: 41839 Bar-Ox Zinc Chromate Primer.
 - c) Moore: Ironclad Retardo Rust Inhibitive Paint #163.
 - d) S-W: Zinc Chromate Primer B50Y1.
2. Undercoat: Weather-resistant, air-drying, semigloss alkyd enamel for use on the exterior over prime-coated aluminum (FS TT-E-489, Class A):
- a) Con-Lux: Enamelite Semi-Luster Series.
 - b) Devoe: 70XX Mirrolac Interior/Exterior Alkyd Enamel.
 - c) Moore: Impervo Enamel #133.
 - d) S-W: Industrial Enamel, B-54Z Series.
3. Finish Coat: Weather-resistant, air-drying, semigloss alkyd enamel for use on the exterior over prime-coated aluminum (FS TT-E-489, Class A):
- a) Con-Lux: Enamelite Semi-Luster Series
 - b) Devoe: 70XX Mirrolac Interior/Exterior Alkyd Enamel.
 - c) Moore: Impervo Enamel #133.
 - d) S-W: Industrial Enamel, B-54Z Series.
- I. Wood - Acrylic Enamel, Semigloss: Two coats over primer with total dry film thickness not less than 2.5 mils:
- 1. Primer: Exterior alkyd or latex primer made for use on wood under an acrylic enamel (FS TT-P-001984):
 - a) Con-Lux: Wood-Plex 700 Primer.
 - b) Devoe: 1102 All-Weather Exterior Alkyd House Paint Primer.
 - c) Moore: Moorwhite Primer #100.
 - d) S-W: A-100 Exterior Latex Wood Primer
 - 2. Undercoat: Semigloss, waterborne, exterior, acrylic enamel made for use as an undercoat over a primer on wood under an acrylic enamel (FS TT-P-1510):
 - a) Con-Lux: Weather-Plex 700 Series

- b) Devoe: 17XX Wonder-Shield Semi-Gloss Exterior Acrylic latex House and Trim Paint.
 - c) Moore: MoorGlo Latex House and Trim Paint #096.
 - d) S-W: A-100 Exterior Latex Satin.
3. Finish Coat: Semigloss, waterborne, exterior, acrylic enamel made for use as a finish coat over an acrylic enamel (FS TT-P-1510):
- a) Con-Lux: Weather-Plex 700 Series.
 - b) Devoe: 17XX Wonder-Shield Semi-Gloss Exterior Acrylic latex House
 - c) Moore: and Trim Paint.MoorGlo Latex House and Trim Paint #096.
 - d) S-W: A-100 Exterior Latex Satin.
- J. Wood - Stained-Varnish: Two coats over sealer over stain plus filler on open-grain wood. Wipe filler before applying first varnish coat.
1. Stain Coat: Match interior stained-varnish finish.
2. Sealer: Phenolic varnish for use on exterior natural-finished woodwork (FS TT-V-119), thinned as recommended by manufacturer:
- a) Con-Lux: Imperial 71 Spararnish
 - b) Devoe: 87 Spar Varnish.
 - c) Moore: Impervo 440 SparVarnish.
 - d) S-W:Exterior Varnish A67V4
3. Undercoat: Phenolic varnish for use on exterior natural-finished woodwork (FS TT-V-119):
- a) Con-Lux: Imperial 71 Spar Varnish
 - b) Devoe: 87 Spar Varnish.
 - c) Moore: Impervo 440 Spar Varnish.
 - d) S-W: Exterior Varnish A67V4.
4. Finish Coat: Phenolic varnish for use on exterior natural-finished

woodwork (FS TT-V-119):

- a) Con-Lux:Imperial 71 Spar Varnish.
- b) Devoe: 87 Spar Varnish.
- c) Moore: Impervo 440 Spar Varnish.
- d) S-W: Exterior Varnish A67V4.

2.3 INTERIOR PAINTING SYSTEMS:

A. Interior Paint Schedule: Provide the paint systems scheduled below for the various substrates, as indicated. Provide a complete paint system by one manufacturer for each substrate. Unless otherwise indicated, provide the following:

- 1. Concrete and masonry (except concrete masonry units and concrete floors): Latex, flat.
- 2. Concrete masonry units (except ground-faced CMU, which is to be left unpainted): Latex, flat.
- 3. Concrete floors: Epoxy, gloss, with anti-slip aggregate.
- 4. Gypsum plaster, veneer plaster, and GFRG: Latex, eggshell.
- 5. Acoustical plaster: Unpainted.
- 6. Gypsum board: Latex, flat.
- 7. Woodwork: Stained-varnish finish, except alkyd, semigloss where painted is indicated.
- 8. Ferrous metal:
 - a) Exposed steel structure: Silicone-alkyd, semigloss.
 - b) Other interior ferrous metal: Alkyd, semigloss.
- 9. Zinc-coated metal: Alkyd, semigloss; except silicone-alkyd where part of ferrous metal assemblies painted with silicone-alkyd.
- 10. Non-ferrous metal: Alkyd, semigloss.
- 11. Cotton and canvass covering over insulation: Latex, flat.
- 12. Mechanical and electrical items (not finish painted): See substrate materials above.

B. Concrete and Masonry (Except concrete masonry units) - Latex, Flat: Two coats.

1. Undercoat: Flat latex-based paint made for use as an undercoat over concrete and masonry under a flat latex paint (FS TT-P-29):
 - a) Con-Lux: Jet-Plex 495 Primer.
 - b) Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
 - c) Moore: Moore's Latex Quick-Dry Prime Seal 201.
 - d) S-W: Pro-Mar 200 Latex Flat B30W200.
2. Finish Coat: Flat latex-based paint made for use as a flat finish over concrete and masonry (FS TT-P-29):
 - a) Con-Lux: Wall-Plex 400 Series.
 - b) Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
 - c) Moore: Regal Wall Satin 215.
 - d) S-W: Pro-Mar 200 Latex Flat Wall Paint B30W200 Series.

C. Concrete and Masonry (Except concrete masonry units) - Alkyd, Semigloss: Two coats over primer with total dry film thickness not less than 3.5 mils.

1. Primer: Flat latex-based paint made for use as a primer over concrete and masonry under an odorless alkyd enamel (FS TT-P-29):
 - a) Con-Lux: Wall-Plex 400 Series.
 - b) Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
 - c) Moore: Moore's Latex Quick-Dry Prime Seal 201.
 - d) S-W: Pro-Mar 200 Latex Flat B30W200.
2. Undercoat: Enamel undercoat made for use on the interior as an undercoat over a primer on concrete or masonry under an odorless alkyd enamel:

- a) Con-Lux: Enamel Underbase 54 White.
 - b) Devoe: 26XX Velour Alkyd Semigloss Enamel.
 - c) Moore: Moore's Alkyd Enamel Underbody 217.
 - d) S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
3. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on concrete and masonry (FS TT-E-509):
- a) Con-Lux: Satin-Lite 900 Series
 - b) Devoe: 26XX Velour Alkyd Semigloss Enamel.
 - c) Moore: Moore's Satin Impervo Enamel 235.
 - d) S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
- D. Concrete and Masonry (Except concrete masonry units) - Epoxy, Semi-Gloss: Two coats over primed surface.
1. Primer: Sealer made for use as a primer over masonry wall surfaces and under an epoxy enamel:
- a) Con-Lux: Jet-Plex 495 Primer.
 - b) Duron: Acrylic Enamel Undercoater.
 - c) Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
 - d) S-W: Kem Cati-Coat Epoxy Filler/Sealer.
2. Undercoat: Epoxy enamel undercoat made for use under a semi-gloss epoxy enamel:
- a) Con-Lux: Epolon Semi-Luster Series.
 - b) Duron: Polyamide Epoxy.
 - c) Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
 - d) S-W: Heavy Duty Epoxy.

3. Finish Coat: Semi-gloss epoxy enamel finish coat made for use over an epoxy enamel undercoat:
 - a) Con-Lux: Epolon Semi-Luster Series.
 - b) Duron: Polyamide Epoxy.
 - c) Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
 - d) S-W: Heavy Duty Epoxy.
- E. Concrete Masonry Units (Except ground-faced CMU, which is to be left unpainted) - Latex, Flat: Two coats over filled surface.
 1. Block Filler: High-performance latex block filler made for use for filling open textured concrete masonry block before application of top coats (FS TT-F-1098):
 - a) Con-Lux: Block-Plex 85 White.
 - b) Devoe: 52901 Bloxfil Acrylic Latex Block Filler.
 - c) Moore: Moorcraft Interior and Exterior Block Filler 173.
 - d) S-W: Heavy-Duty Block Filler B42W46.
 2. Undercoat: Flat latex-based paint made for use as an undercoat over filled concrete masonry block under a flat latex paint (FS TT-P-29):
 - a) Con-Lux: Wall-Plex 400 Series.
 - b) Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
 - c) Moore: Moore's Latex Quick-Dry Prime Seal 201.
 - d) S-W: Pro-Mar 200 Latex Flat B30W200.
 3. Finish Coat: Flat latex-based Paint made for use as a flat finish over filled concrete masonry block (FS TT-P-29):
 - a) Con-Lux: Wall-Plex 400 Series.
 - b) Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
 - c) Moore: Regal Wall Satin 215.

d) S-W: Pro-Mar 200 Latex Flat Wall Paint B30W200 Series.

F. Concrete Masonry Units (Except ground-faced CMU, which is to have clear anti-graffiti coating over unfilled surface) - Alkyd, Semigloss: Two coats over filled surface with total dry film thickness not less than 3.5 mils, excluding filler coat

1. Block Filler: High-performance latex block filler made for use for filling open textured concrete masonry block before application of top coats (FS TT-F-1098):

a) Con-Lux: Block-Plex 85 White.

b) Devoe: 52901 Bloxfil Acrylic Latex Block Filler.

c) Moore: Moorcraft Interior and Exterior Block Filler 173.

d) S-W: Heavy-Duty Block Filler B42W46.

2. Undercoat: Enamel undercoat made for use on the interior as an undercoat over a block filler on concrete masonry block under an odorless alkyd enamel:

a) Con-Lux: Enamel Underbase 54 White.

b) Devoe: 26XX Velour Alkyd Semigloss Enamel.

c) Moore: Moore's Alkyd Enamel Underbody 217.

d) S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.

3. Finish Coat: Semigloss odorless alkyd enamel made for use over a block filler and undercoat on concrete masonry block (FS TT-E-509):

a) Con-Lux: Satin-Lite 900 Series.

b) Devoe: 26XX Velour Alkyd Semigloss Enamel.

c) Moore: Moore's Satin Impervo Enamel 235.

d) S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.

G. Concrete Masonry Units (Except ground-faced CMU, which is to have clear anti-graffiti coating over unfilled surface) - Epoxy, Semi-Gloss: Two coats over filled surface.

1. Filler: Filler made for use as a primer over masonry wall surfaces and under an epoxy enamel:

- a) Con-Lux: Jet-Plex 495 Primer; or Block-Plex Block Filler.
 - b) Duron: Acrylic Enamel Undercoater; or Block Kote Latex Block Filler.
 - c) Moore: IronClad Chemical and Water Resistant Epoxy Enamel; or Moorcraft Interior and Exterior Block Filler.
 - d) S-W: Kem Cati-Coat Epoxy Filler/Sealer; or Heavy Duty Block Filler.
2. Undercoat: Epoxy enamel undercoat made for use under a semi-gloss epoxy enamel:
- a) Con-Lux: Epolon Semi-Luster Series.
 - b) Duron: Polyamide Epoxy.
 - c) Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
 - d) S-W: Heavy Duty Epoxy.
3. Finish Coat: Semi-gloss epoxy enamel finish coat made for use over an epoxy enamel undercoat:
- a) Con-Lux: Epolon Semi-Luster Series.
 - b) Duron: Polyamide Epoxy
 - c) Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
 - d) S-W: Heavy Duty Epoxy.
- H. Concrete Floor Surfaces - Epoxy, Gloss: Two coats over primer, with anti-slip aggregate in finish coat:
1. Primer: Epoxy sealer made for use as a primer over concrete floor surfaces and under an epoxy enamel:
- a) Con-Lux: None required.
 - b) Duron: Acrylic Enamel Undercoater
 - c) Moore: IronClad Chemical and Water Resistant Epoxy Enamel.

- d) S-W: ArmorSeal 3300LV Epoxy Primer/Sealer.
- 2. Undercoat: Epoxy enamel undercoat made for use over an epoxy primer and under a gloss epoxy enamel:
 - a) Con-Lux: Epolon Series with Epolon 145 Reducer.
 - b) Duron: Polyamide Epoxy.
 - c) Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
 - d) S-W: ArmorSeal 1000HS.
- 3. Finish Coat: Epoxy enamel finish coat made for use over an epoxy enamel undercoat:
 - a) Con-Lux: Epolon Series with anti-slip aggregate.
 - b) Duron: Polyamide Epoxy with anti-slip aggregate.
 - c) Moore: IronClad Chemical and Water Resistant Epoxy Enamel with anti-slip aggregate.
 - d) S-W: ArmorSeal 1000HS with anti-slip aggregate.
- I. Gypsum Plaster, Veneer Plaster, and GFRG - Latex, Eggshell (Low-Gloss): Two coats over primer; plus sealer for GFRG.
 - 1. Sealer for GFRG: Same as primer coat, to expose hot spots and facilitate sanding to remove "fiber bloom".
 - 2. Primer: Flat latex-based paint made for use as a primer on plaster under an eggshell latex paint (FS TT-P-29):
 - a) Con-Lux: Jet-Plex 495 Primer.
 - b) Devoe: 36XX Wonder-Tones Latex Flat Wall paint.
 - c) Moore: Moore's Latex Quick-Dry Prime Seal 201.
 - d) S-W: Wall and Wood Primer B99WZ2.

3. Undercoat: Eggshell latex paint made for use over a primer on plaster (Performance requirements of FS TT-P-29):
 - a) Con-Lux: Luster-Plex 2000 Series.
 - b) Devoe: 34XX Wonder-Tones Interior Latex Eggshell Enamel.
 - c) Moore: Regal AquaVelvet 319.
 - d) S-W: Pro-Mar 200 Latex Eggshell Enamel B20W200 Series.
4. Finish Coat: Eggshell latex paint made for use over a primer and undercoat on plaster (Performance requirements of FS TT-P-29):
 - a) Con-Lux: Luster-Plex 2000 Series.
 - b) Devoe: 34XX Wonder-Tones Interior Latex Eggshell Enamel.
 - c) Moore: Regal AquaVelvet 319.
 - d) S-W: Pro-Mar 200 Latex Eggshell Enamel B20W200 Series.
- J. Gypsum Plaster, Veneer Plaster, and GFRG - Alkyd, Semigloss: Two coats over primer with total dry film thickness not less than 2.5 mils; plus sealer for GFRG.
 1. Sealer for GFRG: Same as primer coat, to expose hot spots and facilitate sanding to remove "fiber bloom".
 2. Primer: Flat latex-based paint made for use as a primer on plaster under an odorless alkyd enamel (FS TT-P-29):
 - a) Con-Lux: Jet-Plex 495 Primer.
 - b) Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
 - c) Moore: Moore's Latex Quick-Dry Prime Seal 201.
 - d) S-W: Wall and Wood Primer B99WZ2.

3. Undercoat: Enamel undercoat made for use as an undercoat over a primer on plaster under an odorless alkyd enamel:
 - a) Con-Lux: Enamel Underbase 54 White.
 - b) Devoe: 26XX Velour Alkyd Semigloss Enamel
 - c) Moore: Moore's Alkyd Enamel Underbody 217.
 - d) S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series
 4. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on plaster (FS TT-E-509):
 - a) Con-Lux: Satin-Lite 900 Series.
 - b) Devoe: 26XX Velour Alkyd Semigloss Enamel.
 - c) Moore: Moore's Satin Impervo Enamel 235.
 - d) S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
- K. Gypsum Board - Latex, Flat: 1 coat over primer.
1. Primer: Latex-based white primer made for use on interior gypsum board under a flat latex paint (FS TT-P-650):
 - a) Con-Lux: Jet-Plex 495 Primer.
 - b) Devoe: 50801 Wonder-Tones Latex Primer and Sealer.
 - c) Moore: Moore's Latex Quick-Dry Prime Seal 201.
 - d) S-W: Pro-Mar 200 Latex Wall Primer B28W200.
 2. Finish Coat: Flat latex-based paint made for use as a flat finish over prime-coated gypsum board (FS TT-P-29):
 - a) Con-Lux: Wall-Plex 400 Series.
 - b) Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.

- c) Moore: Regal Wall Satin 215.
 - d) S-W: Pro-Mar 200 Latex Flat Wall Paint B30W200 Series.
- L. Gypsum Board - Alkyd, Semigloss: Two coats over primer with total dry film thickness not less than 2.5 mils.
- 1. Primer: Latex-based white primer made for use on interior gypsum board under an odorless alkyd enamel (FS TT-P-650):
 - a) Con-Lux: Jet-Plex 495 Primer.
 - b) Devoe: 50801 Wonder-Tones Latex Primer and Sealer.
 - c) Moore: Moore's Latex Quick-Dry Prime Seal 201.
 - d) S-W: Pro-Mar 200 Latex Wall Primer B28W200.
 - 2. Undercoat: Enamel undercoat made for use on the interior as an undercoat over a primer on interior gypsum board under an odorless alkyd enamel:
 - a) Con-Lux: Enamel Underbase 54 White.
 - b) Devoe: 26XX Velour Alkyd Semigloss Enamel.
 - c) Moore: Moore's Alkyd Enamel Underbody 217.
 - d) S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
 - 3. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on interior gypsum board (FS TT-E-509):
- M. Woodwork, Stained-Varnish: Two coats over sealer over stain plus filler on open-grain wood. Wipe filler before applying first varnish coat.
- a) Con-Lux: Satin-Lite 900 Series.
 - b) Devoe: 26XX Velour Alkyd Semigloss Enamel.
 - c) Moore: Moore's Satin Impervo Enamel 235.
 - d) S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
- 1. Stain Coat: Slow-penetrating oil-type wood stain made for general use on interior

wood surfaces under a varnish finish (FS TT-S-71):

- a) Devoe: 96XX Wonder Woodstain Alkyd Stain.
 - b) Moore: Moore's Interior Wood Finishes Penetrating Stain 241.
 - c) S-W: Oil Stain A-48 Series.
2. Sealer: Quick-drying, rosin-free, clear, general-purpose shellac varnish made for use on the interior over stained-finished woodwork under a varnish finish (FS TT-S-300, Grade A):
- a) Devoe: 4900 Wonder Woodsealer Quick-Dry Sealer.
 - b) Moore: Moore's Interior Wood Finishes, Quick-Dry Sanding Sealer 413.
 - c) S-W: Pro-Mar Varnish Sanding Sealer B26V3.
3. Filler: Solvent-based, air-drying, paste-type wood filler made for use on open-grain wood on interior wood surfaces (FS TT-F-336):
- a) Devoe: 4800 Wonder Woodstain Interior Paste Wood Filler.
 - b) Moore: Benwood Paste Wood Filler.
 - c) S-W: Sher-Wood Fast-Dry Filler.
4. Undercoat: Clear varnish made for use on interior stained-finished woodwork (FS TT-V-86):
- a) Devoe: 4600 Wonder Wood Satin Alkyd Satin Varnish.
 - b) Moore: Benwood Satin Finish Varnish 404.
 - c) S-W: Oil Base Varnish, A66V91/A66F90.
5. Finish Coat: Clear varnish made for use on interior stained-finished woodwork (FS TT-V-86):
- a) Devoe: 4600 Wonder Wood Satin Alkyd Satin Varnish.
 - b) Moore: Benwood Satin Finish Varnish 404.

c) S-W: Oil Base Varnish, A66V91/A66F90.

N. Woodwork, Painted - Alkyd, Semigloss: Two coats over primer.

1. Primer: Enamel undercoat made for use as a primer over wood under an odorless alkyd enamel:

a) Con-Lux: Enamel Underbase 54 White.

b) Devoe: 50501 Interior Alkyd Primer and Vapor Barrier

c) Moore: Moore's Alkyd Enamel Underbody 217.

d) S-W: Wall and Wood Primer B49WZ2.

2. Undercoat: Semigloss odorless alkyd enamel made for use over a primer on wood (FS TT-E-509):

a) Con-Lux: Satin-Lite 900 Series.

b) Devoe: 26XX Velour Alkyd Semigloss Enamel.

c) Moore: Moore's Satin Impervo Enamel 235.

d) S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.

3. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on wood (FS TT-E-509):

a) Con-Lux: Satin-Lite 900 Series.

b) Devoe: 26XX Velour Alkyd Semigloss Enamel.

c) Moore: Moore's Satin Impervo Enamel 235.

d) S-W: Pro-Mar Alkyd Semi-Gloss enamel

B34WZ11 Series

O. Ferrous Metal - Silicone-Alkyd, Semigloss: Two coats over primer:

1. Primer: Lead and chromate-free high solids primer which chemically

inhibits rusting and is recommended by the manufacturer for

application to steel which has been prepared in accordance with
SSPC SP2. Rated 10 (less than 0.01% surface rusting) when tested
in accordance with ASTM B117 for 500 hours. Exceeds
performance requirements of FS TT-P-636:

- a) Con-Lux: Rust Arrestor 50.
- b) S-W: Kem Kromik Universal Metal Primer B50NZ6.
- c) Tnemec: Series P10.

2. Undercoat: Alkyd enamel recommended by
manufacturer of finish coat as an intermediate coat over
specified primer for application of silicone-alkyd finish coat:

- a) Con-Lux: Ferrox Primer.
- b) S-W: Silicone Alkyd Enamel B-56 Series.
- c) Tnemec: Series 23 Enduratone.

3. Finish Coat: Silicone-alkyd enamel with a minimum of 30% silicone
content meeting the qualitative requirements of FS TT-E-490:

- a) Con-Lux: Steel-Master 9500 Series.
- b) S-W: Silicone Alkyd Enamel B-56 Series.
- c) Tnemec: Series 82 Silicone-Alkyd Enamel.

P. Ferrous Metal - Alkyd, Semigloss: Two coats over primer with
total dry film thickness not less than 2.5 mils.

- 1. Primer: Quick-drying, rust-inhibiting primer made for

priming ferrous metal under an odorless alkyd enamel (FS

TT-P-664):

- a) Con-Lux: Ferrox Primer.
- b) Devoe: 41820 Bar-Ox Alkyd Shop/Field Primer.
- c) Moore: Ironclad Retardo Rust-Inhibitive Paint 163
- d) S-W: Kem Kromik Metal Primer B50N2/B50W1.

2. Undercoat: Enamel undercoat made for use as an undercoat over a primer on ferrous metal under an odorless alkyd enamel:

- a) Con-Lux: Satin-Lite 900 Series.
- b) Devoe: 26XX Velour Alkyd Semigloss Enamel.
- c) Moore: Moore's Alkyd Enamel Underbody 217.
- d) S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.

3. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on ferrous metal surfaces (FS TT-E-509):

- a) Con-Lux: Satin-Lite 900 Series.
- b) Devoe: 26XX Velour Alkyd Semigloss Enamel
- c) Moore: Moore's Satin Impervo Enamel 235.
- d) S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.

- Q. Ferrous Metal - Epoxy, Gloss: Two coats over primer:

1. Primer: Corrosion-inhibitive primer recommended by manufacturer for priming ferrous metal under an epoxy undercoat:

- a) Con-Lux: Epolon Mastic 36 White.
- b) Duron: Dura Clad Universal Phenolic Alkyd Fast Dry Metal

Primer.

c) Moore: IronClad Epoxy Rust Inhibitive Primer

d) S-W: Recoatable Epoxy Primer.

2. Undercoat: Epoxy undercoat made for use as an undercoat over a primer on metal under a gloss epoxy enamel:

a) Con-Lux: Epolon Series.

b) Duron: Dura Clad Polyamide Epoxy.

c) Moore: IronClad Chemical and Water Resistant Epoxy Enamel.

d) S-W: ArmorSeal 100HS Series.

3. Finish Coat:

a) Gloss epoxy enamel made for use over a primer and epoxy undercoat on metal surfaces.

1) When the finish coat is applied to a floor surface, add anti-slip aggregate.

b) Con-Lux: Epolon Series.

c) Duron: Dura Clad Polyamide Epoxy.

d) Moore: IronClad Chemical and Water Resistant Epoxy Enamel.

e) S-W: ArmorSeal 100HS Series.

R. Zinc-coated Metal - Alkyd, Semigloss: Two coats over primer, with total dry film thickness not less than 2.5 mils.

1. Primer: Galvanized metal primer made for use on zinc-coated (galvanized) metal surfaces (FS TT-P-641), or one of the following:

a) Con-Lux: Bond-Plex 46 Barrier Green.

b) Devoe: 13201 Mirrolac Galvanized Metal Primer.

c) Moore: Ironclad Galvanized Metal Latex Primer 155.

d) S-W: Industrial Water Based Acrylic Paint B42W110.

2. Undercoat: Enamel undercoat made for use as an undercoat over a primer on zinc-coated metal under an odorless alkyd enamel:
 - a) Con-Lux: Satin-Lite 900 Series.
 - b) Devoe: 26XX Velour Alkyd Semigloss Enamel.
 - c) Moore: Moore's Alkyd Enamel Underbody 217.
 - d) S-W: Pro-Mar Alkyd Semi-Gloss Enamel
B34WZ1100 Series.

3. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on zinc-coated (galvanized) metal surfaces (FS TT-E-509):
 - a) Con-Lux: Satin-Lite 900 Series.
 - b) Devoe: 26XX Velour Alkyd Semigloss Enamel.
 - c) Moore: Moore's Satin Impervo Enamel 235.
 - d) S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.

S. Zinc-Coated Metal - Silicone-Alkyd, Semigloss: Two coats over factory-applied primer:

1. Primer: Galvanized metal primer used to prime zinc-coated (galvanized) metal surfaces (FS TT-P-641), or one of the following.
 - a) Con-Lux: Bond-Plex 46 Barrier Green.
 - b) Devoe: 13201 Mirrolac Galvanized Metal Primer.
 - c) Moore: Ironclad Galvanized Metal Latex Primer #155. d)
S-W: Industrial Water Based Acrylic Paint B42W110.
2. Undercoat: Alkyd enamel recommended by manufacturer of finish coat as an intermediate coat over factory-applied primer for application of silicone-alkyd finish coat:
 - a) Con-Lux: FerroX Primer.
 - b) S-W: Silicone Alkyd Enamel B-56 Series.
 - c) Tnemec: Series 23 Enduratone.

3. Finish Coat: Silicone-alkyd enamel with a minimum of 30% silicone content meeting the qualitative requirements of FS TT-E-490:

- a) Con-Lux: Steel-Master 9500 Series.
- b) S-W: Silicone Alkyd Enamel B-56 Series.
- c) Tnemec: Series 82 Silicone-Alkyd Enamel.

T. Zinc-Coated Metal - Epoxy, Gloss: Two coats over primer:

1. Primer: Primer recommended by manufacturer for priming galvanized metal under an epoxy undercoat:

- a) Con-Lux: Metal Bond 47 Primer.
- b) Duron:
 - (1) Vinyl Wash Primer for surfaces subject to abrasion;
 - (2) Dura Clad Acrylic Galvanized Metal Primer for surfaces not subject to abrasion.
- c) Moore: IronClad Galvanized Metal latex Primer.
- d) S-W: ArmorSeal 100HS Series.

2. Undercoat: Epoxy undercoat made for use as an undercoat over a primer on metal under a gloss epoxy enamel:

- a) Con-Lux: Epolon Series.
- b) Duron: Dura Clad Polyamide Epoxy.
- c) Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
- d) S-W: ArmorSeal 100HS Series.

3. Finish Coat;

- a) Gloss epoxy enamel made for use over a primer and epoxy undercoat on metal

surfaces.

- (1) When the finish coat is applied to a floor surface, add anti-slip aggregate.

- b) Con-Lux: Epolon Series.
- c) Duron: Dura Clad Polyamide Epoxy.
- d) Moore: IronClad Chemical and Water Resistant Epoxy Enamel.
- e) S-W: ArmorSeal 100HS Series.

U. Non-Ferrous Metal - Alkyd, Semigloss: Two coats over primer with total dry film thickness not

less than 2.5 mils.

1. Primer: Corrosion inhibitive primer recommended by manufacturer for priming non-ferrous metal under an odorless alkyd enamel:
 - a) Con-Lux: Bond-Plex 46 Barrier Green.
 - b) Devoe: 13201 Mirrolac Galvanized Metal Primer.
 - c) Moore: Ironclad Retardo Rust-Inhibitive Paint 163.
 - d) S-W: Kem Kromik Metal Primer B50N2/B50W1.
2. Undercoat: Enamel undercoat made for use as an undercoat over a primer on non-ferrous metal under an odorless alkyd enamel:
 - a) Con-Lux: Satin-Lite 900 Series.
 - b) Devoe: 26XX Velour Alkyd Semigloss Enamel.
 - c) Moore: Moore's Alkyd Enamel Underbody 217.
 - d) S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100 Series.
3. Finish Coat: Semigloss odorless alkyd enamel made for use over a primer and undercoat on non-ferrous metal surfaces (FS TT-E-509):

- a) Con-Lux: Satin-Lite 900 Series.
- b) Devoe: 26XX Velour Alkyd Semigloss Enamel.
- c) Moore: Moore's Satin Impervo Enamel 235.
- d) S-W: Pro-Mar Alkyd Semi-Gloss Enamel B34WZ1100

V. Cotton or Canvas Covering over Insulation - Latex, Flat: 2 coats.

1. Undercoat: Flat latex-based paint with fungicidal agent added (to render fabric mildew- proof) made for use as a sealing coat (size) on cotton or canvas covering over insulation:

- a) Con-Lux: Wall-Plex 400 Series.
- b) Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
- c) Moore: Regal Wall Satin 215.
- d) S-W: Pro-Mar 200 Latex Flat Wall Paint B30W200 Series.

2. Finish Coat: Flat latex-based paint with fungicidal agent added (to render fabric mildew- proof) made for use as a sealing coat (size) on cotton or canvas covering over insulation:

- a) Con-Lux: Wall-Plex 400 Series.
- b) Devoe: 36XX Wonder-Tones Latex Flat Wall Paint.
- c) Moore: Regal Wall Satin 215.
- d) S-W: Pro-Mar 200 Latex Flat Wall Paint B30W200 Series.

PART 3 - EXECUTION

3.1 PREPARATORY WORK:

- A. Minimum surface preparation shall be SSPC-SP6 for the steel framing supporting the Crystal City cooling tower. Inspect surfaces for their suitability to receive a finish. In the event that imperfections due to materials or workmanship appear on

surfaces, make the appropriate corrections at no additional cost to the Authority. Correct damage to painted or decorated finishes due to carelessness or negligence of other trades.

- B. Protect hardware, hardware accessories, plates, lighting fixtures and similar items installed prior to painting; remove protection upon completion of each space. Where necessary to remove installed products to ensure their protection, arrange for removal and reinstallation by mechanics of the trade involved. Disconnect equipment adjacent to walls; where necessary, move to permit painting of wall surfaces, and following completion of painting, replace and reconnect.
- C. Clean surfaces to be painted as necessary to remove dust and dirt. Sand as necessary to properly prepare surfaces to receive paint or varnish.
- D. Wash metal surfaces with benzine or mineral spirits to remove dirt, oil or grease before applying paint. Where rust or scale is present, wire brush or sandpaper clean before painting. Apply galvanized metal primer to degreased galvanized metal before applying additional coats.
- E. Prepare masonry surfaces to be painted by removing dirt, dust, oil and grease stains and efflorescence. The method of surface preparation is at the discretion of the Contractor provided that the results are approved. Clean masonry and plaster surfaces to be painted until they are free from alkali and thoroughly dry before applying paint. Test masonry and plaster surfaces for alkali, using red litmus paper, prior to painting.
- F. Clean concrete surfaces free from dirt, or film left from form oil or concrete curing compounds, or loose or excess mortar. Steam clean or wash the surfaces with water. Use cleaning additive with discretion, in accordance with paint manufacturer's recommendation and to the satisfaction of Engineer.
- G. Cut out cracks, scratches and other imperfections in plaster surfaces as required, fill with spackling compound and sand flush with adjacent surface. Fill voids in concrete with cement grout before painting.
- H. Fill nail holes and cracks after first coat with non-shrinking putty of a color to match that of the finish.
- I. Sand, dust and touch up scratches, abrasions or other disfigurements and remove foreign matter from prime coats before proceeding with the following coat. Feather edge spot priming or spot coating into adjacent coatings to produce a smooth and level surface.

- J. Test concrete and plaster surfaces for moisture, using moisture meter, prior to painting. Do not apply paint to surfaces having meter reading above 15.
- K. Caulk joints between door and window frames and walls, and other joints as necessary.
- L. Coordinate the work of this section with the work of other trades.

3.2 APPLICATION:

- A. Touch-up painting of structural steel, miscellaneous metal, hollow-metal doors and frames, and other materials which have been prime coated as may be required where the shop coat has been damaged by welding or abrasion during the handling and erection operations; also rivets, bolts and welds which are unpainted after assembly and erection.
- B. Apply paint by spray in accordance with the manufacturer's directions to achieve required dry film thickness (DFT). Where specifically approved by the Engineer, use rollers or brushes as best suited for material being applied. For covers on rollers use carpet with velvet back and high-pile sheep's wool or use short-hair covers, as best suited for material and texture specified. Except where otherwise noted, apply paint to a minimum dry-film thickness (DFT) of five mils, excluding filler coats, using no less than the number of coats specified in Part 2 – Products.
- C. Apply material evenly and smoothly without runs, sags or other defects with edges of paint adjoining other materials or color sharp and clean, without overlapping.
- D. Do not paint and finish while surfaces are damp. Allow sufficient time between coats, in accordance with manufacturer's directions to produce an evenly smooth finish.
- E. Do not apply final coats until after other trades, whose operations would be detrimental to finish painting, have finished their work in the areas to be painted and the areas have been approved for painting.

3.3 PROTECTION:

- A. Dispose of soiled cleaning rags and waste at the close of each day's work or store such soiled rags and waste in metal containers with tight-fitting covers. Provide buckets of sand during painting operations for use in the event of fire.

Post NO SMOKING signs as necessary and as directed.

- B. Protect the work of other trades against damage or injury by use of suitable covering during the progress of the painting and finishing work. Repair damage to the satisfaction of the Engineer.

3.4 CLEANING:

- A. Upon completion of work, remove staging, scaffolding and containers from the site. Remove paint spots, oil or stains from glass, floors and other surfaces not to be painted, and leave job clean and acceptable to the Engineer.

3.5 COLOR CODING OF PIPING AND EQUIPMENT:

A. General Requirements:

1. Color coding is required for accessible piping systems and related equipment, except associated supports, brackets, hangers and similar accessories.
2. Identify piping systems and related equipment which are to be color coded as follows:
 - a. Apply color to entire length of piping.
 - b. Apply lettered legends indicating the name of the contents of the system as specified.

B. Location of Legends and Bands:

1. Stencil lettered legends on the piping at the horizontal or vertical centerline. Where pipe lines are too close together and where located above the operator's normal line of vision, place the lettering below the horizontal centerline at a point which will be easily visible.
2. Locate lettered legends and bands at points where pipes enter and leave rooms or spaces, at junction points and points of distribution, close to valves and equipment, at changes in direction, and at intervals along piping where necessary for identification.
3. Stencil piping in accordance with ASME A13.1 and as follows to show service and direction of flow, space within sight of each other and not more than 40 feet apart on long runs.

C. Schedule of Colors and Legends:

Line	Pipe Color	Black Stenciled Legend
1. Hot water lines	Yellow	HW, HWR
2. Portable cold water lines	Blue	CW
3. Chilled water lines	Blue and Yellow Band	CHWS, CHWR

4. Fire lines	Red	F (use white stencil instead of black)
5. Condensate lines	White	C
6. Condenser water lines	White with Blue Band	CWS, CWR
7. Soil and waste lines	White	S
8. Vent lines	Grey with white band	V
9. Storm water lines	White	ST-W
10. Air and control air lines	Green	A

Outside Diameter of Pipe Covering in Inches	Size of Letter in Inches	Width of Color Band in Inches
3/4 to 1-1/4	1/2	4
1-1/2 to 2-1/2	3/4	6
3 to 6	1-1/4	8
7 to 10	2-1/2	12
Over 10	3-1/2	12

* * *

END OF SECTION

SECTION 15050

BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. This Section includes the following basic mechanical materials and methods to complement other Division 15 Sections.
 - 1. Piping materials and installation instructions common to most piping systems.
 - 2. Concrete base construction requirements.
 - 3. Escutcheons.
 - 4. Dielectric fittings.
 - 5. Equipment nameplate data requirements.
 - 6. Nonshrink grout for equipment installations.
 - 7. Field-fabricated metal and wood equipment supports.
 - 8. Installation requirements common to equipment specification sections.
 - 9. Mechanical demolition.
 - 10. Cutting and patching.
 - 11. Touchup painting and finishing.
- B. Pipe and pipe fitting materials are specified in Division 15 piping system Sections.

1.2 DEFINITIONS:

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
- F. The following are industry abbreviations for plastic materials:
 - 1. ABS: Acrylonitrile-butadiene-styrene plastic.
 - 2. CPVC: Chlorinated polyvinyl chloride plastic.
 - 3. NP: Nylon plastic.
 - 4. PE: Polyethylene plastic.
 - 5. PVC: Polyvinyl chloride plastic
- G. The following are industry abbreviations for rubber materials:
 - 1. CR: Chlorosulfonated polyethylene synthetic rubber.
 - 2. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.3 SUBMITTALS:

- A. Product Data: For dielectric fittings, flexible connectors, mechanical sleeve seals, and identification materials and devices.
- B. Retain below if procedures for welder certification are retained in "Quality Assurance" Article.

Shop Drawings: Detail fabrication and installation for metal and wood supports and anchorage for mechanical materials and equipment.
- C. Coordination Drawings: For access panel and door locations.
- D. Coordination Drawings: Detail major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Show space requirements for installation and access. Indicate if sequence and coordination of installations are important to efficient flow of the Work. Include the following:
 - 1. Planned piping layout, including valve and specialty locations and valve-stem movement.

2. Clearances for installing and maintaining insulation.
 3. Clearances for servicing and maintaining equipment, accessories, and specialties, including space for disassembly required for periodic maintenance.
 4. Equipment and accessory service connections and support details.
 5. Exterior wall and foundation penetrations.
 6. Fire-rated wall and floor penetrations.
 7. Sizes and location of required concrete pads and bases.
 8. Scheduling, sequencing, movement, and positioning of large equipment into building during construction.
 9. Floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
- E. Samples: Of color, lettering style, and other graphic representation required for each identification material and device.

1.4 QUALITY ASSURANCE:

- A. Comply with ASME A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.
1. Equipment Selection: Equipment of higher electrical characteristics, physical dimensions, capacities, and ratings may be furnished provided such proposed equipment is approved in advance by appropriate Contract Modification for these increases. If minimum energy ratings or efficiencies of equipment are specified, equipment must meet design and commissioning requirements.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING:

- A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- B. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, if stored inside.
- C. Protect flanges, fittings, and piping specialties from moisture and dirt.
- D. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.6 SEQUENCING AND SCHEDULING:

- A. Coordinate mechanical equipment installation with other building components.

- B. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for mechanical installations.
- C. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- D. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning before closing in building.
- E. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.
- F. Coordinate installation of identifying devices after completing covering and painting, if devices are applied to surfaces.

PART 2 – PRODUCTS:

2.1 MANUFACTURERS:

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that maybe incorporated into the work include, but are not limited to, the following:
 - 1. Dielectric Unions:
 - a) Hart Industries International, Incorporated
 - b) Watts Industries, Inc.; Water Products Division
 - c) Zurn Industries, Inc.; Wilkins Division
 - 2. Dielectric Flanges:
 - a) Capitol Manufacturing Company
 - b) Central Plastics Company
 - c) Watts Industries, Inc.; Water Products Division
 - 3. Dielectric-Flange Insulating Kits:
 - a) Calpico, Incorporated
 - b) Central PlasticsCompany

4. Dielectric Couplings:

- a) Calpico, Incorporated
- b) Lochinvar Corporation

5. Dielectric Nipples:

- a) Grinnell Corporation; Grinnell Supply Sales Company
- b) Perfection Corporation
- c) Victaulic Company of America

6. Metal, Flexible Connectors:

- a) Grinnell Corporation; Grinnell Supply Sales Company\
- b) Hispan Precision Products, Incorporated
- c) Metraflex Company

7. Rubber, Flexible Connectors:

- a) General Rubber Corporation
- b) Metraflex Company
- c) Red Valve Company, Incorporation

8. Mechanical Sleeve Seals:

- a) Calpico, Incorporation
- b) Metraflex Company
- c) Thunderline/Link-Seal

2.2 PIPE, TUBE, AND FITTINGS:

- A. Refer to individual Division 15 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS:

- A. Refer to individual Division 15 piping Sections for special joining materials not listed below.
- B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of

piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
 - a) Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b) Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
 2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- E. Solder Filler Metals: ASTM B 32.
1. Alloy Sn95 or Alloy Sn94: Approximately 95 percent tin and 5 percent silver, with 0.10 percent lead content.
 2. Alloy E: Approximately 95 percent tin and 5 percent copper, with 0.10 percent maximum lead content.
 3. Alloy HA: Tin-antimony-silver-copper-zinc, with 0.10 percent maximum lead content.
 4. Alloy HB: Tin-antimony-silver-copper nickel, with 0.10 percent maximum lead content.
 5. Alloy Sb5: 95 percent tin and 5 percent antimony, with 0.20 percent maximum lead content.
- F. Brazing Filler Metals: AWS A5.8.
1. BcuP Series: Copper-phosphorus alloys.
 2. Bagl: Silver alloy
- G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- H. Solvent Cements: Manufacturer's standard solvent cements for the following:
1. ABS Piping: ASTM D 2235.
 2. CPVC Piping: ASTM F 493.

3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
4. PVC to ABS Piping Transition: ASTM D 3138.
- I. Plastic Pipe Seals: ASTM F477, elastomeric gasket
- J. Flanged, Ductile-Iron Pipe Gasket, Bolts, and Nuts: AWWA C110, rubber gasket, carbon-steel bolts and nuts.
- K. Couplings: Iron-body sleeve assembly, fabricated to match OD of plain-end, pressure pipes.
 1. Sleeve: ASTM A 126, Class B, gray iron.
 2. Followers: ASTM A47 (ASTM A47M) malleable iron or ASTM A536 ductile iron.
 3. Gaskets: Rubber.
 4. Bolts and Nuts: AWWA C111.
 5. Finish: Enamel paint.

2.4 DIELECTRIC FITTINGS:

- A. General: Assembly or fitting with insulating material isolating joined dissimilar metals, to prevent galvanic action and stop corrosion.
- B. Description: Combination of copper alloy and ferrous; threaded, solder, plain, and weld-neck end types and matching piping system materials.
- C. Insulating Material: Suitable for system fluid, pressure, and temperature.
- D. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).
- E. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 200-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.
- F. Dielectric-Flange Insulation Kits: Field-assembled, companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 1. Provide separate companion flanges and steel bolts and nut for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.

2. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (105 deg C).

2.5 GROUT:

- A. Nonshrink, Nonmetallic Grout: ASTM C1107, Grade B.
 1. Characteristics: Post-hardening, volume-adjusting, dry, hydraulic-cement, grout, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 2. Design Mix: 5000-psi (34.5-Mpa), 28-day compressive strength.
 3. Packaging: Premixed and factory packaged.

PART 3 – EXECUTION

- 3.1 PIPING SYSTEMS - COMMON REQUIREMENTS:
 - A. General: Install piping as described below, unless piping Sections specify otherwise. Individual Division 15 piping Sections specify unique piping installation requirements.
 - B. General Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated, unless deviations to layout are approved on Coordination Drawings.
 - C. Install piping at indicated slope.
 - D. Install components with pressure rating equal to or greater than system operating pressure.
 - E. Install piping in concealed interior and exterior locations, except in equipment rooms and service areas.
 - F. Install piping free of sags and bends.
 - G. Install exposed interior and exterior piping at right angles or parallel to building walls. Diagonal runs are prohibited, unless otherwise indicated.
 - H. Install piping tight to slabs, beams, joists, columns, walls, and other building elements. Allow sufficient space above removable ceiling panels to allow for ceiling panel removal.
 - I. Install piping to allow application of insulation plus 1-inch (24-mm) clearance around insulation.

- J. Located groups of pipes parallel to each other, spaced to permit valve servicing.
- K. Install fittings for changes in direction and branch connections.
- L. Install couplings according to manufacturer's written instructions. Delete or revise application subparagraphs and associated subparagraphs below as required for escutcheons specified in Part 2.
- M. Piping Joint Construction: Join pipe and fittings as follows and as specifically required in individual piping specification Sections:
 - 1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
 - 2. Remove scale, slag, dirt, and debris from inside and outside of pipe fittings before assembly.
 - 3. Soldered Joints: Construct joints according to AWS's "Soldering Manual," Chapter "The Soldering of Pipe and Tube."
 - 4. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 - 5. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as following:
 - a) Note internal length of threads in fittings or valve ends, and proximity of internal seal or wall, to determine how far pipe should be threaded into joint.
 - b) Apply appropriate tape or thread compound to external pipe threads, unless dry seal threading is specified.
 - c) Align threads at point of assembly.
 - d) Tighten joint with wrench. Apply wrench to valve end into which pipe is being threaded.
 - e) Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- F. Welded Joints: Construct joints according to AWS D10.12, "Recommended Practices and Procedures for Welding Low Carbon Steel Pipe," using qualified processes and welding operators according to "Quality Assurance" Article.

- G Flanged Joints: Align flange surfaces parallel. Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using torque wrench.
- H. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join pipe and fittings according to the following:
1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 2. ABS Piping: ASTM D 2235 and ASTM D 2661.
 3. CPVC Piping: ASTM D 2846 and ASTM F 493.
 4. PVC Pressure Piping: ASTM D2672.
 5. PVC Nonpressure Piping: ASTM D 2855.
 6. PVC to ABS Nonpressure Transition Fittings: Procedure and solvent cement according to ASTM D 3138.
- I. Plastic Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657 procedures and manufacturer's written instructions.
- 1 Plain-End Pipe and Fittings: Use butt fusion.
 2. Plain-End Pipe and Socket Fittings: Use socket fusion.
- N. Retain paragraph above or below.
- O. Piping Connections: Make connections according to the following, unless otherwise indicated:
1. Install unions, in piping 2-inch NPS (DN50) and smaller, adjacent to each valve and at final connection to each piece of equipment with 2-inch NPS (DN50) or smaller threaded pipe connection.
 2. Install flanges, in piping 2-1/2-inch NPS (DN65) and larger, adjacent to flanged valves and at final connection to each piece of equipment with flanged pipe connection.

3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connection piping materials of dissimilar metals.

3.2 EQUIPMENT INSTALLATION – COMMON REQUIREMENTS:

- A. Install equipment to allow maximum possible headroom, if mounting heights are not indicated.
- B. Install equipment according to approved submittal data. Portions of the Work are shown only in diagrammatic form. Refer conflicts to Architect.
- C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- D. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- E. Install equipment giving right of way to piping installed at required slope.
- F. Install flexible connectors on equipment side of shutoff valves, horizontally and parallel to equipment shafts if possible.

3.3 PAINTING AND FINISHING:

- A. Refer to Division 9 Section "Painting" for paint materials, surface preparation, and application of paint.
- B. Apply paint to exposed piping according to the following, unless otherwise indicated:
 1. Interior, Ferrous Piping: Use semigloss, acrylic-enamel finish. Include finish coat over enamel undercoat and primer.
 2. Interior, Galvanized-Steel Piping: Use semigloss, acrylic-enamel finish. Include two finish coats over galvanized metal primer.
 3. Interior, Ferrous Supports: Use semigloss, acrylic-enamel finish. Include two finish coats over enamel undercoat and primer.

- C. Do not pain piping specialties with factory-applied finish.
- D. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.4 CONCRETE BASES:

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - 1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
 - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
 - 7. Use 3000-psi (20.7-Mpa), 28-day compressive-strength concrete and reinforcement.

3.5 ERECTION OF METAL SUPPORTS AND ANCHORAGES:

- A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.
- B. Field Welding: Comply with AWS D1.1, "Structural Welding Code–Steel."

3.6 DEMOLITION:

- A. Disconnect, demolish, and remove Work specified in Division 15 Sections.
- B. If pipe, ductwork, insulation, or equipment to remain is damaged or disturbed, remove damaged portions and install new products of equal capacity and quality.
- C. Accessible Work: Remove indicated exposed pipe and ductwork in its entirety.
- D. Work Abandoned in Place: Cut and remove underground pipe a minimum of 2 inches beyond face of adjacent construction. Cap and patch surface to match existing finish.
- E. Removal: Remove indicated equipment from Project site.
- F. Temporary Disconnection: Remove, store, clean, reinstall, and make operational equipment indicated for relocation.

3.7 CUTTING AND PATCHING:

- A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces necessary for mechanical installations. Perform cutting by skilled mechanics of trades involved.
- B. Repair cut surfaces to match adjacent surfaces.

3.8 GROUTING:

- A. Install nonmetallic, nonshrink, grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors. Mix grout according to manufacturer's written instructions.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placing of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases to provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout according to manufacturer's written instructions.

* * *

END OF SECTION

SECTION 15055
COMMON MOTOR & MOTOR CONTROLLER REQUIREMENTS
FOR HVAC EQUIPMENT

PART 1. GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. Section includes general requirements for single-phase and poly-phase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.
 - 1. The motor requirements described in this section apply to all Div. 15 sections, unless specifically modified in an individual section.
- B. Section include the requirements for variable frequency drives up to 600V and installed at equipment manufacturer's factory, shipped separately by equipment manufacturer for field installation, or provided separately for field installation.
 - 1. The variable frequency drive requirements described in this section apply to all Div. 15 sections, unless specifically modified in an individual section.

1.03 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.
- B. Provide all Variable Frequency Drives of a single manufacturer.

PART 2. PRODUCTS

2.01 GENERAL MOTOR REQUIREMENTS

- A. Comply with NEMA MG 1 unless otherwise indicated.

- B. Comply with IEEE 841 for severe-duty motors.

2.02 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.03 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Premium, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Rotor: Random-wound, squirrel cage.
- E. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- F. Temperature Rise: Match insulation rating.
- G. Insulation: Class F.
- H. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- I. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.04 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 - 2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.05 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
 - 2. Split phase.
 - 3. Capacitor start, inductor run.
 - 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

2.06 VARIABLE FREQUENCY DRIVES (VFD)

- A. General Requirements for VFDs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.
- B. Application: variable torque.
- C. VFD Description: Variable-frequency power converter (rectifier, dc bus, and IGBT, PWM inverter) factory packaged in an enclosure, with over-current and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
 - 1. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, 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."
 - 2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section V, Part 31, "Definite-Purpose Inverter-Fed Poly-phase Motors."
 - 3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
- D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
- E. Output Rating: Three-phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range maximum voltage equals input voltage.
- F. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of VFD input voltage rating.
 2. Input AC Voltage Unbalance: Not exceeding 5 percent.
 3. Input Frequency Tolerance: Plus or minus 3 percent of VFD frequency rating.
 4. Minimum Efficiency: 97 percent at 60 Hz, full load.
 5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.
 6. Minimum Short-Circuit Current (Withstand) Rating: 22 kA.
 7. Ambient Temperature Rating: Not less than 14 deg F and not exceeding 104 deg F Ambient
Storage Temperature Rating: Not less than minus 4 deg F and not exceeding 140 deg F.
 8. Humidity Rating: Less than 95 percent (non-condensing).
 9. Altitude Rating: Not exceeding 3300 feet.
 10. Vibration Withstand: Comply with IEC 60068-2-6.
 11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base
load current for three seconds.
 12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
 13. Speed Regulation: Plus or minus 5 percent.
 14. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
 15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
- G. Inverter Logic: Microprocessor based, 16 bit, isolated from all power circuits.
- H. Isolated Control Interface: Allows VFDs to follow remote-control electrical signal over a minimum 40:1
speed range.
- I. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
 2. Maximum Speed: 80 to 100 percent of maximum rpm.
 3. Acceleration: 0.1 to 999.9 seconds.
 4. Deceleration: 0.1 to 999.9 seconds.
 5. Current Limit: 30 to minimum of 150 percent of maximum rating.
- J. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
 2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
 3. Under and overvoltage trips.
 4. Inverter over-current trips.
 5. VFD and Motor Overload/Over-temperature Protection: Microprocessor-based thermal protection system for monitoring VFDs and motor thermal characteristics, and for providing VFD over-temperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved.
 6. Critical frequency rejection, with three selectable, adjustable dead-bands.
 7. Instantaneous line-to-line and line-to-ground over-current trips.
 8. Loss-of-phase protection.
 9. Reverse-phase protection.
 10. Short-circuit protection.
 11. Motor over-temperature fault.
- K. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.
- L. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Auto-speed Search" feature is available and engaged.
- M. Bidirectional Auto-speed Search: Capable of starting VFD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.
- N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- O. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- P. Integral Input Disconnecting Means and OCPD: NEMA AB 1, molded-case switch, with power fuse block and current-limiting fuses with pad-lockable, door-mounted handle mechanism.
1. Disconnect Rating: Not less than 115 percent of VFD input current rating.
 2. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFD input current rating, whichever is larger.

Q. CONTROLS AND INDICATION

1. Status Lights: Door-mounted LED indicators displaying the following conditions:
 - a. Power on.
 - b. Run.
 - c. Overvoltage
 - d. Line fault.
 - e. Over-current.
 - f. External fault.
2. MCC Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
 - a. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
 - b. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
 - 1) Control Authority: Supports at least four conditions: Off, local manual control at VFD, local automatic control at VFD, and automatic control through a remote source.
3. Historical Logging Information and Displays: a.
Running log of total power versus time. b. Total
run time.
c. Fault log, maintaining last four faults with time and date stamp for each.
4. Indicating Devices: Digital display mounted flush in MCC door and connected to display VFD parameters including, but not limited to:
 - a. Output frequency (Hz).
 - b. Motor speed (rpm).
 - c. Motor status (running, stop, fault).
 - d. Motor current (amperes).
 - e. Motor torque (percent).
 - f. Fault or alarming status (code).
 - g. PID feedback signal (percent).

- h. DC-link voltage (V dc).
- i. Set point frequency (Hz).
- j. Motor output voltage (V ac).

5. Control Signal Interfaces:

- a. Electric Input Signal Interface:
 - 1) A minimum of two programmable analog inputs: 4- to 20-mA dc
 - 2) A minimum of **six** multifunction programmable digital inputs.
- b. Remote Signal Inputs: Capability to accept any of the following speed-setting Input signals from the BMS or other control systems:
 - 1) 0- to 10-V dc.
 - 2) 4- to 20-mA dc.
 - 3) Potentiometer using up/down digital inputs.
 - 4) Fixed frequencies using digital inputs.
- c. Output Signal Interface: A minimum of two programmable analog output signal(s) 0- 4- to 20-mA dc which can be configured for any of the following:
 - 1) Output frequency (Hz).
 - 2) Output current (load).
 - 3) DC-link voltage (V dc).
 - 4) Motor torque (percent).
 - 5) Motor speed (rpm).
 - 6) Set point frequency (Hz).
- d. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
 - 1) Motor running.
 - 2) Set point speed reached.
 - 3) Fault and warning indication (over-temperature or over-current).
 - 4) PID high- or low-speed limits reached.

6. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.

- a. Number of Loops: One

7. BMS Interface: Factory-installed hardware and software to enable the BMS to monitor, control, and display VFD status and alarms and energy usage, allows VFD to be used with an external system within a multi-drop LAN configuration; settings retained within VFD's nonvolatile memory.

- a. Network Communications Ports: Ethernet and RS-422/485

- b. Embedded BMS Protocols for Network Communications: ModBus protocols accessible via the communications ports.

R. LINE CONDITIONING AND FILTERING

1. Input Line Conditioning, 3% line reactor.

2. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2.

S. OPTIONAL FEATURES

1. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.

T. ENCLOSURES

1. VFD Enclosures: NEMA 250, to comply with environmental conditions at installed location. a.

- Dry and Clean Indoor Locations: Type 1

- b. Outdoor Locations: Type 3R

- c. Other Wet or Damp Indoor Locations: Type 4

- d. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

U. ACCESSORIES

1. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; installed in MCC enclosure cover unless otherwise indicated.

- a. Push Buttons, Pilot Lights, and Selector Switches: Standard-duty, oil-tight type.

- 1) Push Buttons: Unguarded types; momentary.

- 2) Pilot Lights: LED types; Selector Switches: Rotary type.

2. Reversible NC/NO bypass contactor auxiliary contact(s).

3. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

4. Phase-Failure, Phase-Reversal, and Under-voltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable under-voltage, overvoltage, and time-delay settings.
 - a. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.
5. Supplemental Digital Meters:
 - a. Elapsed time meter.
6. Cooling Fan and Exhaust System: For NEMA 250, Type 1, UL 508 component recognized: Supply fan, with composite intake and exhaust grills and filters; 120 V ac; obtained from integral CPT.

V. SOURCE QUALITY CONTROL

1. Testing: Test and inspect VFDs according to requirements in NEMA ICS 61800-2
2. VFDs will be considered defective if they do not pass tests and inspections.
3. Prepare test and inspection reports.

PART 3 - EXECUTION (Not Applicable)

* * *

END OF SECTION

SECTION 15060

HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. This Section includes hangers and supports for mechanical system piping and equipment.
- B. Related Sections include the following:
 - 1. Division 15 Section Vibration Isolation

1.2 SUBMITTALS:

- A. Product Data: For each type of pipe hanger, channel support system component, and thermal-hanger shield insert indicated.
- B. Welding Certificates: Copies of certificates for welding procedures and operators.

1.3 QUALITY ASSURANCE:

- A. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Pipe Hangers:
 - a) B-Line Systems, Inc.
 - b) Grinnell Corp.
 - c) National Pipe Hanger Corp
- B. Channel Support Systems:

1. B-Line Systems, Inc.
2. Grinnell Corp.; Power-Strut Unit.
3. National Pipe Hanger Corp.

C. Thermal-Hanger Shield Inserts:

1. Carpenter & Patterson, Inc.
2. Michigan Hanger Co., Inc.
3. Pipe Shields, Inc.

D. Powder-Actuated Fastener Systems:

1. Gunnebo Fastening Corp.
2. Hilti, Inc.
3. ITW Ramset/Red Head.

2.2 MANUFACTURED UNITS:

A. Pipe Hangers, Supports, and Components: MSS SP-58, factory-fabricated components.

Refer to "Hanger and Support Applications" Article in Part 3 for where to use specific hanger and support types.

1. Galvanized, Metallic Coatings: For piping and equipment that will not have field-applied finish.
2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

B. Channel Support Systems: MFMA-2, factory-fabricated components for field assembly.

1. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

C. Thermal-Hanger Shield Inserts: (690-kPa) 100-psi minimum compressive-strength insulation, encased in sheet metal shield.

1. Material for Cold Piping: ASTM C 552, Type I cellular glass with vapor barrier. 2.

For Trapeze or Clamped System: Insert and shield cover entire
circumference of pipe.

3. For Clevis or Band Hanger: Insert and shield cover lower 180 degrees of
pipe. 4.

Insert Length: Extend () 2 inches (50 mm) beyond sheet metal shield
for piping operating below ambient air temperature.

2.3 MISCELLANEOUS MATERIALS:

- A. Powder-Actuated Drive-Pin Fasteners: Powder-actuated-type, drive-pin attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.
- C. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars, black and galvanized.
- D. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged, nonshrink and nonmetallic, dry, hydraulic-cement grout.
 - 1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.
 - 2. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 3. Design Mix: (34.5-Mpa) 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS:

- A. Specific hanger requirements are specified in Sections specifying equipment and systems.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Specification Sections.

- C. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
1. Adjustable Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, (DN15 to DN750) NPS ½ to NPS 30.
 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F (49 to 232 deg C) pipes, (DN100 to DN400) NPS 4 to NPS 16, requiring up to 4 inches (100 mm) of insulation.
 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, (DN20 to DN600) NPS ¾ to NPS 24, requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, DN15 to (DN600) NPS ½ to NPS 24, if little or no insulation is required.
 5. Pipe Hangers (MSS Type 5): For suspension of pipes, (DN15 to DN100) NPS ½ to NPS 4, to allow off-center closure for hanger installation before pipe erection.
 6. Adjustable Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, (DN20 to DN200) NPS ¾ to NPS 8.
 7. Adjustable Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, (DN15 to DN200) NPS ½ to NPS 8.
 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, (DN15 to DN200) NPS ½ to NPS 8.
 9. Adjustable Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, (DN15 to DN50) NPS ½ to NPS 2.
 10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, (DN10 to DN200) NPS 3/8 to NPS 8.
 11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For

suspension of noninsulated stationary pipes, (DN10 to DN80) NPS 3/8 to NPS 3.

12. U-Bolts (MSS Type 24): For support of heavy pipe, (DN15 to DN750) NPS ½ to NPS 30.
 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 14. Pipe Saddle Supports (MSS Type 36): For support of pipes, (DN100 to DN900) NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, (DN100 to DN900) NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
 16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, (DN65 to DN900) NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
 17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, (DN25 to DN750) NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, (DN65 to DN500) NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.
 19. Complete Pipe Rolls (MSS Type 44): For support of pipes, (DN50 to DN1050) NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, (DN50 to DN600) NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, (DN50 to DN750) NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- D. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, (DN20 to DN500) NPS 3/4 to NPS 20.
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, (DN20 to DN500) NPS 3/4 to NPS 20, if longer ends are required for riser clamps.
- E. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.
- F. Build system attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 3. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 4. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 5. C-Clamps (MSS Type 23): For structural shapes.
 6. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 7. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 8. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.

9. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 10. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 11. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a) Light (MSS Type 31): 750 lb (340 kg).
 - b) Medium (MSS Type 32): 1500 lb (675 kg). C.
Heavy (MSS Type 33): 3000 lb (1350 kg).
 12. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 13. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 14. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where head room is limited.
- G. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe, 360-degree insert of high-density, (690-kPa) 100-psi minimum compressive-strength, water-repellent-treated calcium silicate or cellular-glass pipe insulation, same thickness as adjoining insulation with vapor barrier and encased in 360-degree sheet metal shield.
- H. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

- a. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
- b. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed (32 mm) 1-1/4 inches.
- c. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
- d. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
- e. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to
25 percent to absorb expansion and contraction of piping system from hanger.
- f. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
- g. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.
- h. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
 - a) Horizontal (MSS Type 54): Mounted

horizontally.
 - b) Vertical (MSS Type 55):

Mounted vertically.
 - c) Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

3.2 HANGERS AND SUPPORT INSTALLATION:

- A. Pipe Hanger and Support Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Channel Support System Installation: Arrange for grouping of parallel runs of

piping and support together on field-assembled channel systems.

1. Field assemble and install according to manufacturer's written instructions. C. Heavy-Duty Steel Trapeze Installation: Arrange for grouping of parallel runs of

horizontal piping and support together on field-fabricated, heavy-duty trapezes.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.

2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.

D. Install building attachments within concrete slabs or attach to structural steel.

E. Install powder-actuated drive-pin fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.

F. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured.
Install fasteners according to manufacturer's written instructions.

G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping," is not exceeded.

J. Insulated Piping: Comply with the following: 1.

Attach clamps and spacers to piping.

- a) Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - b) Do not exceed pipe stress limits according to ASME B31.9.
2. Install MSS SP-58, Type 39 protection saddles, if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span arc of 180 degrees.
 4. Shield Dimensions for Pipe: Not less than the following:
 - a) DN8 to DN90 (NPS ¼ to NPS 3-1/2): 12 inches long (305 mm) and 0.048 inch (1.22 mm) thick.
 - b) DN100 (NPS4): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
 - c) DN125 and DN150 (NPS 5 and NPS 6): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
 5. Insert Material: Length at least as long as protective shield.
 6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3. EQUIPMENT SUPPORTS:

- A. Fabricate structural-steel stands to suspend equipment from structure above or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

3.4 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field-weld connections that cannot be shop-welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and

with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.5 ADJUSTING:

- A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

3.6 PAINTING:

- A. Touching Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 1. Apply paint by brush or spray to provide a minimum dry film thickness of (0.05 mm) 2.0 mils.
- B. Touching Up: Cleaning and touch up painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9 Section "Painting."
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 15070

VIBRATION ISOLATION

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. This section specifies providing vibration isolation for mechanical equipment and piping.

1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
 - 1. Comply with codes and regulations of the jurisdictional authorities
 - 2. ASTM: A123.

1.03 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Shop Drawings:
 - 1. Design for concrete inertia block and structural-steel bases. Include tabulation of design data on isolators including actual deflection; outside diameter; free, operating and solid heights of isolators; method of attachment; bolt sizes; and type and sizes of anchor plates.
- B. Certification.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

- A. General Requirements:
 - 1. Vibration isolators selected to produce uniform loading and deflection even when equipment weight is not evenly distributed; steel components hot-dip galvanized after fabrication in accordance with ASTM A123.
 - a. Types of vibration isolators:
 - b. For equipment and piping:
 - 1) Floor-mounted: Spring isolators.
 - 2) Ceiling-suspended: Suspension-type isolators.
 - 2. Spring isolators for floor-mounted equipment:
 - a. Free-standing, laterally stable without housing, complete with minimum

- 1/4-inch thick neoprene, acoustical friction pad in series with spring element.
 - b. Leveling bolts and adequate facilities for bolting to equipment and supporting structure using isolation washers.
 - c. Coil outside diameter: Not less than 0.8 of operating height of spring.
 - d. Horizontal stiffness: Not less than 0.8 of vertical stiffness.
 - e. Springs designed to have additional 50-percent capacity beyond rated load.
 - f. Springs designed so that ends remain parallel during and after spring deflection to operating height.
 - g. Vibration isolators selected for lowest operating speed of equipment.
 - h. Built-in adjustable limit stops with isolators provided for equipment of operating weight different from installed weights, to prevent rising of equipment when weight is removed and for equipment exposed to wind. Limit stops not to be in contact during normal operating conditions.
 - i. Welding of springs to load-plate assembly for vibration isolators with capacities of 6,000 pounds or less is prohibited.
 - j. Vibration isolators with capacities of 6,000 pounds or less are permitted use of cups or other positive means for restraining springs.
- 3. Suspension-type isolation hangers for ceiling-suspended equipment:
 - a. Combination of spring and neoprene in series.
 - b. Spring made of stable steel.
 - c. Encased in structurally stable steel bracket.
 - d. Spring diameter large enough to permit 15-degree angular misalignment of rod connecting hanger to equipment without rubbing on box
 - e. Designed to provide complete support for suspended units upon failure or rupture of isolator.
- 4. Inertia bases:
 - a. Furnished by vibration-isolator manufacturer.
 - b. Complete with steel-reinforced concrete cast into welded structural-steel channel frame, mounting templates and brackets for vibration isolators with thickness equal to eight-percent minimum of longest base dimension.
 - c. Structural-steel work: Section 05120.
- 5. Concrete equipment subbases (housekeeping pads)
 - a. Concrete: Sections 03100, 03200 and 03300.
 - b. Concrete subbases not less than four inches high provided for floor-mounted equipment. Subbases resting on structural floor and reinforced with steel rods interconnected with reinforcing bars of floor by means of tie bars hooked at both ends.
 - c. Clearance between subbases and inertia bases: Two inches minimum.
 - d. Subbase concrete: Class 2500, Finish No. 4.
- 6. Snubbers:
 - a. As recommended by manufacturer of vibration isolator.
 - b. Compatible with vibration isolators

provided.

B. Isolation-Unit Types and Deflection:

1. Fans, ventilating units, evaporation units and air-conditioning units: Floor-mounted and ceiling-suspended.
 - a. Spring isolators designed for a minimum of 1.5 inches deflection.
 - b. Snubbers: Where shown.
2. Pumps:
 - a. Base-mounted pumps on inertia bases.
 - b. Inertia bases shaped to include base elbow supports for connected piping and at least 1-1/2 times weight of supported equipment or a minimum base thickness of eight percent of longest base dimension, whichever results in greater weight.
 - c. Springs with minimum deflection of 1.5 inches under imposed static load.
3. Chillers:
 - a. Vertically restrained spring isolators designed for 1.5 inches minimum deflection. Inertia bases if recommended by chiller manufacturer.
4. Cooling towers:
 - a. Steel beams mounted on vertically restrained spring isolators designed for 1.5 inches minimum deflection.
 - b. Rails: Acceptable, if performance requirements for spring isolators specified for cooling towers are met.
 - c. Height of steel beams designed to support loads and eight-percent minimum of longest span between isolators.
5. Piping:
 - a. Ceiling-suspended piping: Combination spring and neoprene in shear element hangers as specified for ceiling-suspended equipment. Springs designed for 1.5-inch minimum deflection. First two isolation hangers of each pipe connected to equipment to have deflection equal to equipment isolation-support deflection.
 - b. Floor-mounted piping isolated by spring isolators with one-inch minimum static deflection. First two spring isolators of each pipe connected to equipment to have deflection equal to equipment isolation-support deflection.
6. Grout: Section 03300, premixed shrinkage-compensating grout.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Install vibration isolators where shown as recommended by the equipment manufacturer.

- B. Mount mechanical equipment on vibration isolators to isolate equipment from structure.
- C. Jack bases and equipment into position and wedge or block before vibration isolators are loaded.
- D. Use isolator leveling bolts for final leveling of equipment after equipment is in operation.
- E. Springs installed so that ends remain parallel during and after deflection to operating height.
- F. Mount snubbers as close to vibration isolators as practicable.
- G. Grout void between pump bases and inertia-base concrete.
- H. Piping connected to equipment isolated from structures as follows:
 - 1. Condenser-water piping in its entirety.
 - 2. Chilled-water piping: Piping connected to equipment, mounted on vibration isolators or suspended with vibration hangers, isolated for a distance of 50 feet from equipment.
Piping with installed length less than 50 feet isolated in its entirety only when connected to equipment provided with vibration isolators.
 - 3. Compressed-air piping: Connected to compressors for a distance of 50 feet from compressor. Piping with installed length less than 50 feet isolated in its entirety.

* * *

END OF SECTION

SECTION 15075

IDENTIFICATION OF MECHANICAL EQUIPMENT AND PIPING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. This section specifies providing nameplates and tags on mechanical equipment and apparatus.
- B. Related Work Specified Elsewhere:
 - 1. Field painting: Section 09920.

1.02 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Samples:
 - 1. Labels and tags in each size.
- B. Documentation:
 - 1. Charts for valves; include valve identification number, location and purpose.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

- A. Nameplates: Laminated plastic.
- B. Tags: 18-gauge stainless steel.
- C. Identification Plates: Bronze, Authority-furnished.

PART 3 - EXECUTION

3.01 IDENTIFICATION:

- A. Equipment and Apparatus:
 - 1. Label equipment and apparatus with one-inch high white letters engraved on 1-1/2 inch high, black, laminated-plastic nameplates securely fastened to metal panels, showing function and unit number of item.
 - 2. Identify devices including transducers, controls and switches by means of 1/2-inch high white letters engraved on one-inch high, black, laminated plastic nameplates identifying manufacturer and function of equipment.
 - a. Provide same type nameplates on front cover for each pilot light and for mode-of-operation selector switches. Label positions of mode-selector switches, e.g. AUTOMATIC/OFF/EMERGENCY EXHAUST/EMERGENCY SUPPLY.
 - 3. Nameplates for components located in fan-control cabinets to show symbol used on schematic diagram to represent component. Label fan-control cabinet terminals using same symbols and identification corresponding to that shown on schematic diagram.
- B. Piping:
 - 1. Stencil legends and bands on piping showing service and direction of flow as specified

- in Section 09920.
 - 2. Color coding of exposed piping and terminations of piping is specified in Section 09920.
- C. Valves:
 - 1. Identify valves with 1-1/2 inch diameter, 18-gauge stainless-steel tags.
 - 2. Designate appropriate service on each tag with 1/4-inch stamped black-filled letters and valve number with 1/2-inch stamped black-filled numbers.
- D. Orifice Flange and Venturi Tube:
 - 1. Identify each orifice or venturi tube with integral tab or stainless-steel tag.
 - 2. Stamp on tag differential multiplier, orifice bore, rate of flow and equipment served.

3.02 INSTALLATION:

- A. Cement nameplates with permanent adhesive on equipment and apparatus.
- B. Affix labels to surface of control and switch boxes by means of sheet-metal rivets. Cement labels to surface with permanent adhesive when rivets cannot be used.
- C. Fasten tags securely to valves, orifice flange, venturi tube with brass jack chain, so as to permit easy reading.
- D. Mount valve charts in aluminum frames with clear Lucite front cover in locations as directed.
- E. Fire-Protection and Suppression System:
 - 1. Stencil legends on piping as shown to identify service and direction of flow.
 - 2. Stamp information on Authority-furnished identification plates as shown and fasten to sleeve on siamese fire-department connections for tunnel systems as shown.

* * *

END OF SECTION

SECTION 15080

INSULATION

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. This section specifies providing insulation.

1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
 - 1. Comply with codes and regulations of the jurisdictional authorities.
 - 2. NFPA: 90A.
 - 3. ASTM: C240, C534, C552, C1071, E84.
 - 4. FS: HH-I-558.
 - 5. MS: MIL-A-3316, MIL-B-19564, MIL-C-19565, MIL-C-20079.
 - 6. SMACNA: HVAC Duct Construction Standards – Metal and Flexible
- B. Each item listed in UL Building Materials Directory.
- C. Fire-Hazard Ratings:
 - 1. Determine fire-hazard ratings in accordance with ASTM E84.
 - a. Insulation, fastener, and jacketing materials, except flexible cellular plastic for expansion joints: Not exceeding 25 for flame spread, 50 for fuel contributed and 50 for smoke developed.
 - b. Use of flameproofing and fireproofing treatments for the purpose of achieving specified fire-hazard ratings for insulation not meeting specified requirements is prohibited.

1.03 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Shop Drawings.
- B. Certification.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Label each item with manufacturer's name and brand designation, referenced specification number, type, class and thermal and acoustical rating as applicable.
- B. Ship each type of insulation and accessory materials securely packaged and labeled for safe handling in shipment and to avoid damage.
- C. Store materials in secure and dry storage facility.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

- A. External Ductwork Insulation with Vapor-Barrier Facing: NOT USED
- B. Internal Ductwork Insulation: NOT USED
- C. Piping Insulation:
 - 1. General:
 - a. Vapor-permeance resistance:
 - 1) Maximum vapor permeance: 0.5 percent by volume.
 - 2) Vapor-permeance ratings for piping insulation determined in accordance with ASTM C240.
 - 2. Chilled-water piping insulation:
 - a. Rigid premolded cellular glass: 2" thick, Covered with aluminum jacket 0.016-inch thick; ASTM C552.
 - b. Insulation for buried or embedded pipe: As specified or rigid polyurethane, one-inch thick, ASTM C552.
 - 3. Insulation for pump discharge lines:
 - a. Pipe, valves, flanges and fittings: As specified for chilled-water piping except insulation to consist of one layer, one-inch thick.
 - b. Insulation not required on embedded or buried pipe.
 - 4. Refrigerant-piping insulation: (NOT USED)
- D. Chilled-Water Pump Insulation:
 - 1. Rigid premolded cellular glass: Two inches thick, ASTM C552.
- E. Chiller Insulation:
 - a. Insulation: Semi-rigid fibrous-glass board: 1-1/2 inches thick; FS HH-I-558, Form A, Class 1.
 - b. Cellular glass, rigid blocks or boards: Two inches thick; ASTM C552.
 - 2. Vapor-barrier coating: Resistant to fire and water; MS MIL-C-19565, Type 1.
 - 3. Fire-resistant lagging adhesive: MS MIL-A-3316, Class 1.
 - 4. Metal bands for securing insulation in place: Type 316, stainless steel, minimum thickness 0.016 inches, minimum width 1/2 inch.
 - 5. Glass cloth: MS MIL-C-20079, Type I, Class 2.
- F. Air-Separator Insulation:
 - 1. As specified for chilled-water pump.
- G. Compression-Tank Insulation:
 - 1. As specified for chiller.
- H. Expansion-Joint Insulation: Flexible unicellular, ASTM C534, one-inch thickness, two layers.
- I. Wire Mesh: Galvanized wire, 22-gauge, one-inch mesh welded.
- J. Corner Beads: Galvanized steel, 26-gauge, 2 1/2-inch wings.
- K. Rigid-Insulation Adhesive and Sealer: Cold-applied, nonhardening asphaltic-type, in accordance with MS MIL-B-19564.
- L. Vinyl-Emulsion Mastic: As recommended by manufacturer of rigid insulation.

- M. Bore Coating: Anti-abrasive vinyl-base type as recommended by manufacturer of rigid insulation.
- N. Sheet Metal Duct Lining: Galvanized sheet metal, 22 gauge, perforated with 3/32-inch holes on 3/16-inch centers, with 22-percent open area.
- O. Fabric Pipe Jacket: Prefabricated laminate containing 10-by-10 asphalt-impregnated glass fabric and aluminum foil one-mil thick, sandwiched between three layers of bituminous mastic, for use on embedded or inaccessible piping.
- P. Metal Pipe Jacket:
 - 1. Galvanized sheet steel, 24 gauge (U.S.S.) having Z-type longitudinal joint seam.
 - 2. Aluminum alloy, 0.016-inch thick, mill-finish, having Z-type longitudinal joint seam.
- Q. Insulation-Hanger Shields: Aluminum alloy, minimum 0.050-inch thick, mill-finish, covering bottom 180 degrees of pipe insulation, lengths as follows:

Pipe Sizes/Inclusive	Shield Length
1/2 inch to 2 inches	6 inches
2-1/2 inches to 6 inches	9 inches
6 inches to 12 inches	12 inches

PART 3 - EXECUTION

3.01 APPLICATION OF INSULATION:

- A. General:
 - 1. Do not apply insulation until all surfaces to be covered are clean, dry and free of foreign materials, such as oil, grease, rust, scale and dirt.
 - 2. Apply only clean and dry insulation.
 - 3. Install insulation in accordance with manufacturer's recommendations as a minimum requirement.
 - 4. Provide complete moisture and vapor seal wherever insulation terminates against metal hangers, anchors and other projections through insulation on cold surfaces.
 - 5. Provide continuous insulation through sleeves and openings except pipe sleeves piercing exterior walls, floors and ceilings below ground level.
 - 6. Stagger joints with respect to adjacent butt joints.
 - 7. NOT USED
 - 8. The Contractor has the option of applying insulation internally or externally, except for the following required internal applications:
 - a. Where shown.
 - b. Insulated ductwork exposed to weather.
- B. External Ductwork Insulation (NOT USED):
- C. Internal Ductwork Insulation: (NOT USED)
- D. Chilled-Water Pump Insulation:
 - 1. Rigid premolded cellular glass: Two inches thick, ASTM C552.
- E. Piping Insulation:

1. Chilled-water piping:
 - a. Insulation thickness:
 - 1) Rigid premolded cellular glass:
 - a) Pipe sizes four inches and smaller: Install two layers of one-inch thick insulation on supply and return piping, valves and fittings.
 - b) Pipe size five inches and larger: Install one layer of two-inch thick insulation on supply and return piping, valves and fittings.
 2. Pump discharge lines:
 - a. Install insulation on pump discharge lines, valves, flanges and fittings conforming to insulation installation specified for chilled-water piping except that insulation consists of one one-inch thick layer.
 - b. Asphalt-paper inner jacket not required.
 3. Refrigerant-piping insulation (NOT USED):
 - a. Install insulation consisting of one layer, one-inch thick and finished as specified for chilled-water piping.
 4. Embedded or inaccessible-piping insulation:
 - a. Install insulation consisting of layers or thickness specified for usage specified.
 - b. Provide inner jacket of prefabricated-fabric pipe jacket.
 - c. Coat exposed surface of fabric pipe jacket with protective plastic film and inner surface with special-release paper.
 - d. Apply jacket of galvanized steel over inner jacket.
 - e. For flanges, valves and other fittings, apply aluminum jacket with paper backing or asphalt adhesive over galvanized-steel jacket. Secure by means of straps as specified.
 - f. Over elbows provide mitered insulation covered with aluminum jacket material.
- F. Application of Insulation on Pipe Saddles:
1. Cut two-inch thick piece of premolded pipe insulation of same material as used on piping, slightly larger than void formed by outer pipe circumference and pipe saddle.
 2. Press insulation into void by hand pressure, so that both ends project slightly beyond each end of saddle.
 3. Cut ends of insulation flush with saddle ends.
 4. Use of filler, adhesive or other material to fill voids or imperfections in insulation is prohibited.
- G. Expansion Joints for Piping Insulation:
1. Install expansion joints in both horizontal insulation and vertical runs of piping on centers not to exceed 50 feet.
 2. Install joints one-half inch wide and fill with cushioning material in accordance with insulation manufacturer's recommendations.
- H. Insulation for Anchors:
1. Insulate anchors which are secured directly to cold piping as specified for a minimum distance of eight inches from surface of pipe insulation and sufficient to prevent sweating.
- I. Application of Chilled-Water Pump Insulation:
1. Install two-inch thick insulation as complete unit or in sections, constructed so that insulation can be removed and replaced without damage.
 2. Fit insulation snugly against pump without voids.
 3. Bevel curved surface edges to provide tight joint.
 4. Provide metal insulation covers with metal fasteners, supports, frames and

membranes.

J. Application of Chiller Insulation:

1. Insulate water-cooler shell, water boxes of water cooler, exposed suction piping and cold gas-inlet connection to hermetic-unit motors.
2. Exposed suction piping: As specified for chiller-water piping
3. Cooler shell:
 - a. Cut and miter insulation to fit contour of surface. Secure in place with bands not over 12 inches on center. Stagger and seal joints with vapor-barrier mastic.
 - b. Apply tack coat of adhesive conforming to MS MIL-A-3316, Class 1, at 60 to 70 square feet per gallon by spray or brush. Embed glass cloth into wet coating, smoothing to remove wrinkles. Overlap seams at least two inches. By spray or brush apply finish coat of lagging adhesive to entire fabric surface at rate of 60 to 70 square feet per gallon. Apply finish coat not later than one hour after tack coat.
4. Removable heads and water boxes:
 1. Cover removable heads and water boxes with galvanized-steel box, 22-gauge minimum, constructed as complete unit or in sections. Construction to permit removal and replacement of covers without damage to insulation.
 2. Line metal covers with insulation of type and thickness used for cooler shell. Impale insulation on weld pins and secure with speed washers.
 3. Seal voids and joints with vapor-barrier mastic to prevent infiltration of moisture in space between insulation and metal cover.

k. Application of Compression-Tank Insulation :

1. As specified for chiller.

* * *

END OF SECTION

SECTION 15185

HYDRONIC PUMPS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This section specifies providing chilled-water and condenser-water pumps, complete with motor drives.
- B. Related Work Specified Elsewhere:
 - 2. Insulation: Section 15080.
 - 3. Vibration isolation: Section 15070.
 - 4. Motors: Section 15060.

1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
 - 1. Comply with Codes and Regulations of the jurisdictional authorities.
 - 2. NEC.
- B. Design Criteria:
 - 1. Select pumps based on capacity and total dynamic head shown.
- C. Source Quality Control:
 - a. Test pumps at 1-1/2 times working pressure.
 - b. Balance impeller statically, dynamically and hydraulically.

1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
 - 1. Shop Drawings.
 - 2. Certification.
 - 3. Operation and Maintenance Manuals.

1.04 JOB CONDITIONS:

- A. Safety Requirements:
 - 1. Properly guard belts, pulleys, chains, gears and other rotating parts to prevent danger to personnel.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

- A. General Requirements:
 - a) In design and purchase of equipment, provide for interchangeability of items of piping

equipment, subassemblies, parts, motors, starters and relays.

B. Casings:

1. Close-grained cast iron, volute-type.
2. Horizontal or vertical split case with flanged suction and discharge, designed for optimum-velocity change and hydraulic balance.
3. Openings tapped for suction and discharge gauges, suction chamber, discharge-volute venting and casing drainage.
4. Sections of casings bolted and doweled to permit access to impeller without removal of piping and to provide exact positioning at assembly, after inspection or replacement of parts.
5. Split bearing brackets bolted and doweled for perfect alignment of rotor, wearing rings and bearings.

C. Impeller:

1. Enclosed, double suction, cast bronze, one-piece.
2. Secured to shaft by key and locking collars for exact alignment.
3. Exterior surfaces machined.
4. Interior surfaces and water passages deburred and hand-finished.

D. Casing Wearing Rings:

1. Bronze, renewable-type, locked to prevent rotation.

E. Shafts:

1. Solid, Alloy S30300 stainless steel.
2. Sized to provide maximum 0.002-inch deflection at face of stuffing box.

F. Mechanical Seals:

1. Single, inside-mounted, selection based on pressure, temperature, speed and shaft diameter.
2. Seal parts:
 - a) 150 psi with shaft diameter to three inches:
 - a. Temperature range: 40F to 225F.
 - b. Shaft sealing member: Buna rubber.
 - c. Rotating sealing member: Carbon.
 - d. Metal parts of seal: Brass.
 - e. Stationary sealing member: Nickel-alloy iron.
 - f. Spring: Stainless steel.
 - b) Above 150 psi: As specified for 150 psi with shaft diameter to three inches, except stationary sealing member fabricated of tungsten carbide.

G. Glands:

1. Mechanical seal, flush-type, drilled and tapped to provide clear, filtered liquid flush to seal face with separate stainless cyclone separator.
2. Fabricated of stainless steel, factory-mounted and piped for each seal.

H. Bearings:

1. Grease or oil lubricated, designed for 150,000 hours average life.
2. Bearing housings enclosed and protected from dirt and water.

I. Coupling:

1. Flexible, nonlubricated, pin and bushing.

J. Coupling Guard:

1. Fabricated steel-housing enclosure bolted to base plate.

K. Bedplate:

1. Structural steel, ribbed for rigidity and with minimum five-inch diameter grout holes.
 2. Drip collection chamber provided with ½-inch IPS connection at low point of bedplate.
 3. Drilled and tapped to accommodate pump, motor and coupling guard.
- L. Motors: Section 16225 with the following additional requirements:
1. Sized for nonoverloading operation under all conditions on pump curve.
 2. Four-pole, squirrel-cage induction, dripproof and fully guarded.
- M. Flexible Connection:
1. Reinforced-rubber-type or contour-molded reinforced-Teflon-type with flanged ends at inlet and outlet of pump.
 2. Reinforcement: Monel or stainless-steel rings.
 3. Designed for 150 percent of maximum working pressure.
- N. Vibration Isolators: Section 15070.
- O. Nameplates:
1. Securely attached on each pump showing manufacturer's name, model number and serial number.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Fit equipment and appurtenances within space provided and make readily serviceable.
- B. Provide foundation for proper installation of equipment.
- C. Construct subbases for equipment in accordance with Section 15070.
- D. Insulate pumps as specified in Section 15080.
- E. Make final alignment on pump and motor coupling prior to operation.
- F. Mount pumps on vibration isolators where shown.
- G. Ensure that pump and motor operate without noticeable vibration after installation.

* * *

END OF SECTION

SECTION 15186

WATER TREATMENT SYSTEM

PART 1. GENERAL

1.01 DESCRIPTION:

- A.** This section specifies providing complete Water Treatment for chilled-water and condenser-water systems. The Water Treatment System - Monitoring Panel shall be integrated with/ part of the Chiller Plant Monitoring Panel. See spec Section 15900.
- B.** Related Work Specified Elsewhere
 - 1. Piping systems: Section 15205.
 - 2. Insulation: Section 15080.
 - 3. Vibration isolation: Section 15070
 - 4. HVAC Instrumentation and Controls: Section 15900.
 - 5. System Balancing and Testing: Section 15950.

1.02 QUALITY ASSURANCE:

- A.** Codes, Regulations, Reference Standards and Specifications:
 - 1. Comply with codes and regulations of the jurisdictional authorities.
 - 2. NEMA: 250
- B.** Design Criteria:
 - 1. Provide automatic water-treatment monitoring and control systems to minimize corrosion and prevent fouling of components.
 - 2. Design shall include provide remote monitoring and control of the automated system using Modbus over ModBus RTU.
 - 3. System cleaner: Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products.
 - 4. Chilled water: Select chemicals for control of corrosion, scale and algae that are not toxic to humans in concentrations found in operating system. Closed loop water systems need the following:
 - a. pH control
 - b. An oxygen scavenger
 - c. Bactericide
 - d. Corrosion inhibitor
 - 5. Condenser water: Select chemicals for control of corrosion, scale and algae that are not toxic to humans in concentrations found in operating system. Open loop water systems need the following:
 - a. pH control
 - b. Micro biological controls
 - c. Corrosion inhibitor

1.03 CHEMICAL FEED SYSTEM DESCRIPTION

- A.** Condenser Water Piping and Cooling Tower

1. Pump sequestering agent and corrosion inhibitor from solution tank into condenser water supply to the cooling tower. Use agitator as required.
 2. Intermittently feed biocide and algaecide to condenser water to achieve a toxic level of the chemical to kill the organisms present.
 3. Change biocides periodically to avoid chemical immunity.
 4. Activate chemical solution pump from water meter in makeup water line to cooling tower when condenser water pumps are running.
 5. Automatically feed chemical with electronic solid-state controllers. See Contract Drawing for the design intent.
 6. Deactivate solution pump and signal alarm by a liquid-level switch in each solution tank on low chemicals.
 7. Continuous pH and Conductivity monitoring and correction.
- B. Chilled Water Piping and Chiller**
1. Initial Chiller Plant start-up, Pump sequestering agent and corrosion inhibitor from solution tank into chilled water supply to the chiller. Use agitator as required.
 2. Provide electronic solid-state controllers. See Contract Drawing for the design intent.
 3. Continuous pH and Conductivity monitoring and correction.

1.04 SPECIAL REQUIREMENT:

- A. As part of Chiller Plant Monitoring Panel; Provide automatic water-treatment monitoring and control systems, as indicated in the Contract Drawing.
- B. For Water Treatment; Provide chemical pumps, solution tanks, agitator, liquid-level switches, packaged conductivity controller, cold-water meter, piping, valves, strainers, etc. as indicated in the Contract Drawing.

Provide 3/4-inch branch piping and fittings between the Chilled Water Main and Condenser Water Main which shall be connected to the Water Treatment Valves Assembly. Provide copper pipe, ASTM B88, Type K, hard-drawn, fittings ANSI/ASME B16.22. Piping (maximum 18-inch long) from Valves Assembly to chemical pumps shall be braided stainless steel flexible piping with appropriate connections provided to valves and to pumps at the end.

- C. Provide Shop-Fabricated, Water Treatment Piping Loop and Valve Assembly for Chilled water and Condenser water on steel support angle and steel plate. Properly hang the support plate on wall.
- D. Provide a portable stainless steel bench with wall support, to accommodate 3-chemical pumps for Condenser Water and space for future Chilled Water Pumps, include on-off-auto switches for pumps, indicating light for pump running status, bleed valve on-off and status indicating light, and electrical receptacle for pumps.

1.05 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
 1. Shop Drawings.
 - a. Complete catalog information and shop drawings for material and equipment including wiring and control diagram. Differentiate between manufacturer-installed and field-installed wiring.
 - b. Shop drawings of the Water Treatment Piping and Valve Assembly together with listing of Material, Equipment and Accessories. Indicate Wall support devices.
 - 1) Make sure that the Valve Assembly; including Sample Pet Cock, Strainer, Ball Valves, Flow Switch are installed at 5-feet above finish floor for easy maintenance.
 - c. Shop drawings of portable bench for pumps. Indicate Electrical Receptacle and Wall support devices.
 - d. Coordinate shop drawings of the Chiller Plant Monitoring Panel. See spec Section 15900 and

Contract drawing.

2. Certification
 - a. Manufacturer's certified test reports.
3. Documentation:
 - a. Water analysis:
 - 1) Water-sample analysis. Submit prior to introducing chemicals into systems.
 - b. Chemical-quantity requirements:
 - 1) Submit calculations showing total quantities of various chemicals required for two years operation of water-treatment systems
 - 2) Base quantity of chemicals for 2,000 full-load operating hours per annum for designed tonnage and average of five cycles concentration of condenser water.
 - c. Chemical-quality requirements:
 - d. Submit chemical formulae and descriptions or generic names of materials used.
 - e. Prior to acceptance, submit toxicity data of water treatment complying with applicable codes and regulations of jurisdictional authorities
 - f. If required by the jurisdiction, submit their approval of chemicals proposed for use
4. MSDS approval by WMATA SAFE:
 - a. Submit Manufacturers' Safety Data Sheets (MSDS) for approval by WMATA's Safety Office (SAFE) for use by WMATA personnel and for use in the WMATA system.
5. Operation and Maintenance Manuals.

1.06 JOB CONDITIONS:

- A. Safety Requirements:
 1. Store and handle chemicals so as to prevent danger to personnel.

1.07 FIELD SERVICE:

- A. Engage services of specialist for two years from the day when air-conditioning system is first put into normal and continuous operation, supervise and train plant-operating personnel in correct use of water treatment system. Specialist to be certified by water-treatment system manufacturer as qualified in operation of system provided.
- B. Specialist's services to include the following:
 1. Supervision of pretreatment, startup and adjustment of automatic water-treatment systems.

1.08 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Ship products securely packaged and labeled for safe handling in shipment and to avoid damage and distortion.
- B. Label each item with manufacturer's name, brand, reference specification, type, class and other pertinent information as applicable.
- C. Supply liquid chemicals in thirty-gallon polyethylene-lined steel drums or five-gallon plastic pails.
- D. Ship chemicals which are not used for initial startup to Authority-designated storage facility.
- E. Store products in a secure, dry storage facility.

PART 2. PRODUCTS

2.01 MATERIALS:

- A. General Requirements:
 - 1. In design and purchase of equipment, provide for interchangeability of items of piping equipment, injectors, subassemblies, parts, and controllers.
 - 2. See Contract Drawing for the Design Intent and requirement of the Water Treatment Monitoring System.
- B. Monitoring Systems employ sensors for the continuous real time direct analysis of water chemistry required to control scale, corrosion, and microbiological content.
- C. Chemical Injection Systems adjust water treatment programs based on changing system demands.
- D. Controllers provide for remote monitoring and control of water treatment via ModBus over ModBus RTU.
 - 1. Custom controls that regulate blowdown and chemical feed and immediately communicate upset conditions
 - 2. Web-enabled monitoring and control software to provide performance-based feedback and alerts
- E. Chemical Feeding Equipment:
 - 1. Pot-type chemical feeder shall be included for manual chemical injection as needed:
 - a. Designed and constructed for 150-psig water working pressure.
 - b. Chemical feeder: Minimum capacity, 15 gallons.
 - c. In accordance with applicable codes and regulations for unfired pressure vessels.
 - 2. Packaged Conductivity Controller: HACH Controller, model SC 200 with ModBus Network Module. Conductivity Sensor Module with Electrodeless Conductivity Sensors.
 - 3. Cold-Water Meter: Positive-displacement type with sealed, tamperproof magnetic drive, impulse contact register.
 - a. Rotating-disc type with bronze or cast-iron body rated for 125 psig
 - b. Magnetic-drive matched to signal receiver
 - c. At least six-digit totalizers
 - d. 120V, 60Hz..
 - 4. Solenoid Valves: Forged-brass body, globe pattern, and general-purpose solenoid enclosure with 120V, continuous-duty coil.
 - 5. Chemical Tubing: copper pipe, ASTM B88, Type K, hard-drawn, fittings ANSI/ASME B16.22.).
 - 6. Ball Valves Valves shall be bronze construction, threaded ends type, rated at minimum 150 psi
 - 7. Strainer: bronze cleanable stainless-steel strainer element.
 - 8. Chiller Plant Control Panel, integrating Water-Treatment Control Panel: See spec Section 15900 and Contract Drawing.
 - a. Control dissolved solids, based on conductivity, and include the following:
HACH Controller, model SC 200 with ModBus Network Module
Conductivity Sensor Module with Electrodeless Conductivity Sensors.
Bleed-off light to indicate valve operation.

9. Chilled Water and Condenser Water Loop Flowmeter: Provide Ultrasonic Flowmeter. Siemens Sitrans, model FUS1010 or approved equal; non-intrusive clamp-on flow sensors. wall mounted NEMA 4X enclosure with transmitter, Local Key Pad and Display. ModBus capable to interface with Productivity 3000 System. Provide hardware and software.
- F. Name Plates: Securely attached to each major item of equipment showing manufacturer's name, model number and serial number.

PART 3. EXECUTION

3.01 INSTALLATION:

- A. Fit equipment and appurtenances to space provided and make readily serviceable.
- B. Provide foundations, platforms and hangers for proper installation of equipment.
- C. Provide waste connections for water-treatment equipment as specified in Section 15205.
- D. Insulate piping and equipment in accordance with Section 15080
- E. Install water treatment as per manufacturer's recommendation.

* * *

END OF SECTION

SECTION 15205

PIPING SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. This section specifies providing piping, fittings, valves, drains, specialties and supporting devices.
- B. Related Work Specified Elsewhere:
 - 1. Field painting: Section 09920.
 - 2. Identification of mechanical equipment and piping: Section 15075.
 - 3. Insulation: Section 15080.
 - 4. Grounding and bonding: Section 16060.

1.02 QUALITY ASSURANCE:

- A. Qualifications of Welder: Section 05120.
- B. Codes, Regulations, Reference Standards and Specifications:
 - 1. Comply with codes and regulations of the jurisdictional authorities.
 - 2. The Model Plumbing Code.
 - 3. ASSE Standards.
 - 4. AWWA Standards.
 - 5. ASME Code for Unfired Pressure Vessels.
 - 6. ANSI/ASME: A21.15/C115, B16.1, B16.3, B16.5, B16.9, B16.11, B16.18, B16.22, B16.39, B31.1, Z21.22.
 - 7. ANSI/AWS: A5.8, E8016, E8018.
 - 8. CISPI: HSN 85.
 - 9. FS: A-A-1192, SS-C-153C, WW-P-51F, WW-P-460D, WW-P-501, WW-U-516B, WW-U-531, WW-V-51F.
 - 10. MSS: SP-58, SP-67, SP-70, SP-80.
 - 11. PDI: WH-201.
 - 12. ASTM: A53, A74, A105, A126, A234, A276, A395, A536, B32, B61, B62, B88, B150, B280, B306, F709.

1.03 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Shop Drawings:
 - 1. Complete catalog information and shop drawings for material and equipment.
 - 2. Submittals include, but are not limited to, the following:
 - a. Pipes and piping layout, including locations of hangers and supports.
 - b. Pipe hangers and supports.
 - c. Valves.
 - d. Cleanout deck plates and wall plates.
 - e. Escutcheons.
 - f. Gauges.
 - g. Expansion joints, guides and anchors.
 - h. Air eliminators.
 - i. Pipe sleeves.

- j. Drains.
- B. Certification:
 - 1. Certificates from manufacturers verifying the following:
 - a. That pipe-joint gaskets and lubricants are satisfactory for use with pipe and fittings specified.
 - b. That Mechanical joints and Expansion joints are designed and tested as specified.

1.04 JOB CONDITIONS:

- A. Do not perform welding when the temperature of base metal is less than zero degree F.
- B. Do not perform welding when surfaces are wet from rain, snow, ice or during periods of high wind unless operator and work are properly protected.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

- A. General Requirements:
 - 1. In design and purchase of equipment, provide for interchangeability of items of piping equipment, subassemblies and parts.
- B. Piping:
 - 1. Cast-iron soil pipe and fittings (NOT USED):
 - 2. Steel pipe and fittings:
 - a. Seamless piping: ASTM A53, Types Grade B, hot-dip galvanized, Schedule 40, provided for the following applications:
 - 1) Chilled-water and condenser-water supply and return embedded .
 - b. Fittings for chilled water, condenser water: ASTM A234 and ANSI/ASME B16.9 for dimensions and tolerances but not chemical properties.
 - c. Flanges: ASTM A105 and ANSI/ASME B16.5 for dimensions and tolerances.
 - d. Fittings and flanges furnished with properties equal to or greater than that of adjacent pipe.
 - 3. Ductile-iron pipe and fittings (NOT USED):
 - 4. Copper tubing and fittings:
 - a. Copper tubing for potable water and for control air where embedded or otherwise inaccessible: ASTM B88, Type K, hard-drawn.
 - b. Provide copper tubing for potable water, control air and pneumatic sewage-ejector compressed air where accessible: ASTM B88.
 - 1) Potable water and control air: Type M.
 - 2) Potable water and control air installed in conduit: Type K, annealed and lengths of piping 100 feet or less continuous without joints.
 - 3) Pneumatic sewage-ejector compressed air: Type K, hard-drawn.
 - c. Fittings for potable-water piping: ANSI/ASME B16.22.
 - 1) Fitting wall thickness after forming not less than that of adjacent piping.
 - d. Fittings for control-air piping: Wrought copper, solder joint except at apparatus connections where brass compression fittings furnished.
 - e. Maximum pressure drop for high-pressure control-air mains: Five psi per 1,000 feet, with minimum 1-1/2 cubic feet per minute of 75-psi air flowing for each single station served and one cubic foot per minute for chilled-water

- plant.
 - 1) Minimum size for high-pressure control-air mains connecting chiller plants and underground stations: One-half inch ID, 5/8-inch OD.
 - f. Control-air piping graded to low points and each low point provided with 3/8-inch drain cock.
 - g. Solder joints: Lead-free 95.5-percent tin, 4.0-percent copper and 0.5-percent silver with non-corrosive flux; ASTM B32.
 - 5. Copper drainage tube (DWV) and fittings : Blow down pipe
 - 6. Copper tubing for refrigerant service (NOT USED):
 - 7. Condensate-drain pipes:
 - a. Hard-drawn copper: ASTM B88, Type L.
 - 8. Unpolished stainless-steel drip pans:
 - a. Provided under water, waste or condensate-drain piping which run over transformer vaults or electric motor starters.
 - b. Each drip pan provided with one-inch drain.
 - 9. Black-steel seamless pipe and fittings:
 - a. Exposed and or inaccessible located chilled water, condenser-water supply and return piping: ASTM A53, Standard Weight Schedule 40. Standard wall thickness for Grooved Mechanical Joints.
 - b. Pipes 1-1/2 inch and smaller connected with socket-weld fittings or Grooved Mechanical Joint fittings.
 - c. Pipes two inches and larger connected with welded fittings.
 - d. Pipes larger than 12 inches in diameter: Minimum 3/8-inch wall.
 - e. Threaded-pipe fittings: FS WW-P-501, Type I, Class B.
 - f. Welding fittings made of same schedule or weight classification as the pipe.
 - 1) Factory-made welding fittings.
 - 2) Mitered joint elbows and field-made reducers will not be permitted.
 - g. Butt-welded fittings larger than 1-1/2 inches: ANSI/ASME B16.9.
 - h. Socket-welding fittings: ANSI/ASME B16.11.
 - i. Flanges for welded piping system: ANSI/ASME B16.5, forged steel, welded-neck type, 150-pressure class.
 - 10. Grooved Mechanical Joint Fittings: Victaulic or approved equal. Ductile iron ASTM A536, Grade 65-45-12; or ASTM A106, Grade B Steel Fittings with Grooves or Shoulders designed to accept grooved end couplings.
 - 11. Grooved Mechanical Joint Couplings: Victaulic Style 77, or approved equal. Ductile iron housing and synthetic rubber gasket (Grade E EPDM) of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings. Bolt/ nuts: heat treated carbon steel, zinc electroplated to ASTM B633 Track-head conforming to physical properties of ASTM A183.
 - 12. Unions:
 - a. 1-1/2 inch and smaller: Threaded, ASME B16.39, Type A or B to match piping.
 - b. Two inch and larger unions: ASTM A126, Class B, flanged.
 - 1) Two, 2-1/2 and three-inch union flanges: Steel, FS WW-U-531 or of cast iron, ANSI/ASME B16.1, 125-pound class.
 - c. Four inch and larger union: Forged steel, 150-pound class, slip-on weld-neck flanges, ANSI/ASME B16.5.
 - d. Nonferrous-piping unions: Brass, FS WW-U-516B.
 - 13. Cleanouts (NOT USED):
- C. Valves:
- 1. Gate valves two inches or smaller:
 - a. MSS SP-80, Type 2, Class 150.
 - b. Bronze with threaded ends, rough bodies and finished trim.
 - c. Materials except hand wheels: ASTM B61.
 - d. Furnished with malleable-iron hand wheels.
 - a. Gate valves 2-1/2 inches and three inches:

- b. MSS SP-70, Type 3, Class 125, OS&Y flanged end, Type I, Class 2, cast-iron bodies and bonnets.
 - c. Seat rings, disc, disc guide and stem furnished in bronze.
 - d. Outside stem and yoke (OS&Y), flanged-end connections and malleable-iron hand wheels.
- 2. Gate valves four inches and larger:
 - a. MSS SP-70, Type 2, Class 125, OS&Y, flanged end, cast-iron bodies and bonnets.
 - b. Seat rings, disc, disc guide and stem furnished in bronze.
 - c. Outside stem-and-yoke type and cast-iron hand wheels.
- 3. Globe, angle and check valves:
 - a. Two inches and smaller:
 - 1) WW-V-51F, Class B.
 - 2) Bronze with threaded ends, rough bodies and finished trim.
 - 3) Materials except hand wheels: ASTM B61.
 - 4) Globe and angle valves furnished with malleable-iron hand wheels.
 - 5) Check valves four inches and larger:
 - a) Swing-type valve seat, with iron or steel body and cap and flanged-end connections.
 - b) 150-pound class, renewable arm, disc assembly and seat ring with bronze trim.
- 4. Valves for copper piping:
 - a. Gate valves with solder ends: MSS SP-80, Type 2, Class 150, Bronze, Type 1, Class B.
 - b. Gate valves with flanged ends: MSS SP-80, Type 2, Class 150, Bronze.
 - c. Globe, angle and check valves with solder or flanged ends: FS WW-V-51F, Bronze, Class B.
- 5. Pressure-reducing valves:
 - a. Direct-acting type in which diaphragm and spring act directly on valve stem.
 - b. Constructed to ensure that delivered pressure does not vary more than one psi for each ten-psi variation in inlet pressure.
 - c. Wearing parts readily renewable.
 - d. Valves two inches and smaller designed for working pressure of 250 psi, brass construction except yoke connecting valve body to separate diaphragm chamber having brass cover and assembled with brass bolts.
 - e. Valves larger than two inches designed for minimum 125 psi, iron bodies and bronze trim.
 - f. Adjustable to any outlet pressure.
 - g. Gate valve and union on both inlet and outlet connections.
 - h. Provided with bypass one pipe-size smaller than main water line.
 - i. Stem-mounted pressure-reducing valve gauges, 3-1/2 inch dial, solid brass or stainless steel case and connections with T-handle stops.
 - j. Pressure-reducing valve strainer: Brass, removable without disconnecting piping.
 - 1) Strainers two inches and smaller: Brass, bodies designed for minimum working pressure of 250 psi.
 - 2) Strainers 2-1/2 inch and larger: Iron bodies designed for minimum working pressure of 125 psi
- 6. Pressure-temperature relief valves:
 - a. Temperature-and-pressure-actuated type, adjustable, bronze, single disc with bottom guide to ensure proper seating.
 - b. Body, disc and base: Bronze, ASTM B62.
 - c. Spring and stem: Steel.
 - d. Lever: Malleable iron.
 - e. Pressure range from three psi to 250 psi rated and tested under ANSI/ASME Z21.22.
 - f. Temperature range: To 400F.
- 7. Automatic flow-control valve:
 - a. Individually selected by manufacturer to automatically limit rate of flow to

- design capacity, regardless of system fluctuations.
- b. Selected to regulate flow within five percent of nameplate rating of system in which installed. Maximum operating differential between body tappings necessary for control not to exceed two psi.
 - c. Self-cleaning, cartridge-piston type with stainless-steel variable-area orifices.
 - d. Designed for minimum of 125 psi or 150 percent of system working pressure, whichever is greater.
 - e. Tamperproof with body tappings for connecting instruments for verifying flow-control performance.
 - f. Threaded or flanged connections as required for pipe fittings.
 - g. Furnished with valve kit consisting of 1/8-inch by two-inch minimum size nipples, shutoff valves located outside of insulation and hose fittings for use with measuring instruments.
8. Refrigerant valves: UL listed.
9. Balancing cocks:
- a. Resilient-faced, eccentric-plug type designed for minimum of 125 psi or 150 percent of system working pressure, whichever is greater.
 - b. Six inches and under, wrench-operated; eight inches and over, operated by worm or spur gear.
10. Line Strainers:
- a. Water strainers, Y or basket-type, 1-1/2 inches and smaller: ASTM A126, Grade B, iron bodies with screwed connections.
 - b. Two inches and larger: ASTM A126, Grade B, iron bodies with flanged-end connections.
 - c. Designed for minimum of 125 psi or 150 percent of system working pressure, whichever is greater.
 - d. Stainless-steel or Monel screens as follows:

1) Perforations:

Strainer size	Perforation size
3/4-inch to two-inch inclusive	1/32 inch
2-1/2 inch to six-inch inclusive	1/16 inch
Eight-inch to 12-inch inclusive	1/8 inch
Over 12 inches	5/32 inch

- 2) Free area of screen minimum three times area of strainer inlet pipe.
- e. Strainer provided with 3/4-inch drain valve.
11. Backflow preventer:
- a. Reduced-pressure type with two check valves and automatically operated pressure-differential relief valve located between two check valves.
 - b. Relief valve and discharge port to drain intermediate chamber to level below supply-line inlet.

- c. Moving parts and trim constructed of corrosion-resistant material.
- d. Equipped with test cocks.
- e. Conform to applicable section of ASSE and AWWA Standards.
- 12. Butterfly valves:
 - a. MSS SP-67, sizes as shown.
 - b. Provide extended necks or neck extenders to accommodate two inches of insulation.
 - c. Provide 10-position latch-lock handles.
 - d. Provide enclosed work screw operators, sizes eight inches and larger.
 - e. Provide chainwheels when above normal reaching area.
 - f. Provide adjustable balance-return stops for balancing service.
 - g. Meeting MSS SP-67.
 - h. Test shell at 225 psi.
 - i. Body:
 - 1) Wafer-type, cast iron, ASTM A126, Class B, or lug-type, ductile iron, ASTM A536 grade 60-40-18, or ASTM A395.
 - 2) To fit between ANSI/ASME B16.5 flanges.
 - 3) Bodies with integral flanges or full lugs drilled.
 - j. Seat:
 - 1) Provide ethylene-propylene-terpolymer (EPT) bonded to rigid ring providing noncollapsible and replaceable seat.
 - 2) Provide bubble-tight shutoff of 150 psi at temperatures between 25F and 225F.
 - 3) Provide O-ring as secondary seal between seat and stem.
 - k. Disc:
 - 1) Aluminum-bronze: ASTM B150.
 - l. Stem:
 - m. Stainless steel: AISI Type 304, 316, 410 or 416.
 - 1) Isolate from contact with piped material.
- D. Portable Flow Meters:
 - 1. Factory-fabricated case, carrying handle and fitted to hold meter securely to accommodate the following accessories:
 - a. Two 10-foot lengths of connecting hose with female connectors for venturi-tube pressure-tap nipples.
 - 1) Hose designed for minimum of 125 psi or 150 percent of system working pressure, whichever is greater.
 - 2) Completely assembled three-valve manifold with two block valves and vent and drain valves piped and mounted on base.
 - b. Set of curves showing flow versus pressure differential for each orifice or venturi tube.
 - c. Metal instruction plate, secured inside cover, illustrating use of meter.
- E. Orifices and Venturis:
 - 1. Stainless steel, square-edge type, mounted between pipe flanges with factory-made pressure taps.
 - 2. Taps with shut-off valves and with quick-connection hose fittings for portable meters.
 - 3. Orifice-throat diameter at specified flow and differential pressure in inches water gauge as follows:
 - a. Fall in 60 to 80 percent of full scale reading for square-root meters.
 - b. Twelve to 40 inches for linear-scale meters.
 - 4. Venturi size selected with design flow rate between 10 and 40 inches of water-pressure differential.
 - a. Permanent pressure loss: 25-percent maximum of indicated flow-rate differential pressure.
 - 5. Flow-metering equipment: Supplied by same manufacturer.
- F. Thermometers:

1. Dial-type, chromium-plated case, remote or direct-type bulb with accuracy of plus-or-minus one degree.
 - a. Three-inch minimum dial with white face and black digits, graduated in two-degree increments.
 2. Liquid-in-glass thermometers.
 3. Thermometer ranges suitable for service at not less than 20 degrees above controlled temperature settings.
- G. Thermometer Wells:
1. Stainless steel with portions surrounding bulbs not over 1/16-inch thick, designed to hold engraved-stem thermometer.
 2. Six inches projecting two inches into pipe with dust-excluding caps with gaskets and chains.
 3. Pipe smaller than 2-1/2 inches enlarged where wells are located.
 4. Set vertical or at angle to retain oil.
- H. Gauges:
1. ASTM F709, Class 1, 2 or 3, Style A, Type I or III with metal case.
 2. Gauges shall be large faced, liquid filled with a surge and vibration snubber; Ashcraft Duralife Plus gauge or equivalent.
 3. Gauge selection for range and accuracy shall consider high static heads at gauge location.
- I. Shock Absorbers (NOT USED):
- J. Expansion Joints:
1. General:
 - a. Designed for 150 psi and 200F for systems operating at 100 psi or less.
 - b. Provide expansion joint traverse with 150 percent of pipe expansion resulting from temperature variation of 80F.
 - c. Provide corrugated-bellows expansion joints for pipe expansion of 1-1/2 inches or less, minimum of 200 percent of expansion.
 - d. 1-1/2 inches and smaller, threaded ends; two inches and larger, flanged ends.
 2. Flexible ball joints:
 - a. Carbon steel, providing 360 degrees rotation plus 15 degrees minimum angular-flexing movement, furnished with asbestos-composition gaskets, steam-molded in steam-heat presses.
 3. Corrugated-bellows expansion joints:
 - a. Bellows constructed of single-ply or multiple-ply, formed, corrugated stainless steel for pipe sizes smaller than three inches.
 - b. Self-equalizing type with equalizing or reinforcing rings, internal-telescoping stainless-steel or Monel sleeves, removable steel housing to protect bellows and support insulation.
 - c. Corrugated element: Seamless tubing or of single sheet of metal rolled into cylinder having one longitudinal seam for sizes up to 16 inches.
 - d. Joints 2-1/2 inches and smaller: Internal guides and limit stops.
 - e. Designed for a minimum life of 5,000 full-rated traverse cycles when tested at specified pressures and temperatures.
- K. Supporting Devices:
1. Pipe hangers and supports:
 - a. Provide adjustable steel pipe hangers and supports as follows:
 - 1) Clevis and clamp, cadmium-plated or zinc-plated: MSS SP-58, Type 1 and Type 8 for steel and cast-iron piping.
 - 2) With cast-iron roller and sockets: MSS SP-58, Type 41 for chilled-water piping.

- 3) Space not greater than six feet for pipe sizes up to and including 1-1/2 inches; 10 feet for pipe sizes two inches through six inches; 16 feet for pipe sizes eight inches and larger.
- b. Pipe hangers for copper tubing: Steel, copper-plated, clevis-type, spaced at maximum five feet for tubing sizes through 1-1/2 inches and maximum eight feet for sizes two inches and larger.
- c. Hanger rods minimum diameter 3/8 inch, constructed of steel, cadmium-plated, threaded full-length and diameter required by pipe size and load imposed.
- d. Hanger rod nuts and washers: Steel, cadmium-plated.
- e. Supported from malleable-iron, hot-dip galvanized inserts in concrete slab: MSS SP-58, Type 18.
- f. Pipe hangers and supports in tunnels and shafts: MSS-SP-58, stainless steel, ASTM A276, Type 304.
2. Pipe rolls, plates and stands:
 - a. Cast iron: MSS SP-58, Types 44, 45, and 46.
 - 1) Adjustable types selected for piping require grading after setting in place.
 - b. Protection saddles for support piping: MSS SP-58, Type 39, welded to pipe.
3. Pipe anchors:
 - a. Designed to withstand five times anchor load minimum.
 - b. Vertical pipes anchored by means of clamps welded around pipes and secured to wall or floor construction.
4. Pipe guides:
 - a. Factory-made cast semi-steel or heavy fabricated galvanized steel, consisting of bolted two-section outer cylinder and base with two-section guiding spider bolted or welded tight to pipe.
 - b. Designed to clear pipe insulation and to prevent overtravel of spider and cylinder.
 - c. Guides not less than 12 inches long and spiders not less than the following:

Pipe size/ inches	Spider length/ inches
1-1/2 and smaller	2
2 to 3	2-1/2
4	3
5 and larger	3-1/2

5. Expansion bolt anchors:
 - a. Consisting of bolt, expander, star lock washer and nut.
 - b. Fabricated of stainless steel, Type 303, including expander and star lock washer.
 - c. Anchor assemblies: FS: A-A-1992, Group II, Type 4, Class 1.
6. Self-drilling anchors:
 - a. Self-drilling expansion anchors, with self-cutting annular broaching grooves.
 - b. Anchor and expander plug: FS: A-A-1992, Group III, Type 1, double-plated.
7. Pipe sleeves:
 - a. Through interior masonry-unit walls: As shown. Sleeve to be large enough to accommodate pipe and covering but not less than two sizes larger than pipe size.
 - b. Through poured-concrete interior walls, floors and ceiling: As shown.
 - 1) Sleeves minimum two sizes larger than pipe. At floors, sleeves to project four inches above finish floor.
 - c. Through exterior structural elements: Minimum two sizes larger than pipe and as shown.
 - d. Sleeves designed to allow expansion/contraction movement of pipe.
8. Escutcheon plates:
 - a. Polished brass or stainless steel, screw-fastened to wall or ceiling.
 - b. Plate collars caulked watertight with mastic.
 - c. Mastic: FS SS-C-153C, Type I.
- L. Drains (NOT USED):
- M. Air Separators:
 1. Provide in-the-pipeline air separators with tangential openings for water in and out.
 2. Design to create low-velocity vortex for internal separation of free air from water stream.
 3. Size according to size of connecting pipeline as shown.
 4. Equip with two-inch blowdown connection located at bottom of separator.
 5. Equip with 1-1/4 inch minimum compression tank connection located at top of tank.
 6. Tank:
 - a. Size as shown and rated at 125-psi working pressure.
 - b. Construct of carbon steel and in accordance with ASME Code for Unfired Pressure Vessels and so certified and stamped.
 7. Strainer:
 - a. Stainless steel with perforations sized for water flow.
 - b. Install in location to assist in separation of air.
 - c. Removable from bottom of separator.
 8. Insulation: Section 15080.
- N. Coal-Tar Epoxy Coating: NOT USED

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Welding Procedure:
 1. Perform welding by manual metallic arc-process except for pipe sizes four inches and smaller where gas welding (oxyacetylene) may be used.
 - a. Use electrodes and rods of composition recommended for pipe by AWS.
 - b. Heat surface within three inches from point where weld will start to temperature warm to the hand before welding.

2. Weld corrosion-resistant nickel-copper alloy steel pipe by arc-process utilizing low-hydrogen electrodes of AWS E8016 or E8018 types.
 3. Leave joint surfaces smooth, uniform, free from fins, tears and other defects which adversely affect proper welding.
 4. After each pass of weld on multiple-pass welding, clean weld free of slag and other deposits before applying next pass.
 5. Peen with light blows of blunt-nosed peening hammer.
 - a. Do not peen surface layers or first pass in groove welds.
 6. For groove welds, have surface pass substantially centered on the seam, smooth and free from depressions.
 7. Perform fillet-welds with minimum cutting back of outside pipe.
 - a. Leave throat of full fillet-weld not less than 0.707 of thickness of pipe.
 - b. Repair excess cutting back and undercutting of base metal in pipe adjoining weld.
 - c. Fill up craters to full cross section of weld.
 8. Align and position accurately joints to be welded, so that pipe will not project beyond its adjoining pipe by more than 20 percent of pipe wall thickness or 1/8-inch maximum.
 9. Install welded pipe in accordance with ANSI/ASME B31.1.
- B. Drainage-Piping Installation:
1. Grade piping to 1/4 inch per foot and not less than that of main drain to which it is connected.
 2. Use reducers to change pipe sizes on vent and drain lines.
 3. Use long-sweep bends, Y-fittings, 1/8 or 1/16-bends, or combination Y and 1/8-bends to make changes in direction.
 4. Cut ends of screw-jointed pipes squarely to seat in bottom of recess of fittings and ream after cutting so waterway is not reduced in size.
 5. Apply thread dope or compound to male thread only.
- C. Buried Ductile-Iron Pipe (NOT USED):
1. Install pipe with mechanical joints and neoprene gaskets and stabilize by use of thrust blocks.
 2. Thrust blocks: Not Used
- D. Potable-Water System Installation:
1. Connect and install service water piping, sizes as shown, to fixtures, equipment and outlets.
 2. Install water meter in accordance with requirements of local water authority and provide the following valves:
 - a. Main shut-off gate valve inside service room ahead of water meter.
 - b. Drain with globe valve and hose nipple for 3/4-inch hose installed on house side of meter.
 3. Pipe or tubing free from cuts, dents and other surface damage. Remove damaged pipe and replace with new pipe or tubing.
 4. Cut square and ream ends of copper tubing.
 5. Tubing ends to extend full depth of fitting recesses without binding.
 6. Use lead-free 95.5-percent tin, four-percent copper and 0.5-percent silver solder with non-corrosive flux; ASTM B32.
 7. Ream and clean ends of threaded pipes before assembling with fittings and apply approved joint compound to pipe thread only.
 8. Make connections to equipment and fixtures without undue strain.
 9. Run horizontal piping with minimum pitch of one inch in 40 feet and arrange for drains at low points.

- a. Install drain valves and hose nipples not smaller than 3/4 inch at low points.
 10. Connect nonferrous piping to ferrous piping with dielectric couplings.
 11. Install pressure-reducing valves where main water pressure exceeds 60 psi to maintain pressure of 15 psi at most remote fixture.
- E. Control-Air Piping Installation:
 1. Do not run piping concealed under duct insulation, inside of ducts or in direct contact with surfaces colder than normal room temperature.
- F. Steel-Pipe Installation:
 1. Weld embedded pipe and install so that pipe will not penetrate construction joints or structural contraction joints.
 2. Install horizontal piping with minimum pitch of one inch in 40 feet and arrange for drains at low points.
 - a. Install drain valves and hose nipples not smaller than 3/4 inch at low points.
 3. Install high-capacity automatic air vents at high points, designed for 125 psi and suitable for operation on pressures under 125 psi.
 - a. Pipe air-vent outlet to floor drains.
 4. Pipe drip pan to discharge as shown; if not shown, discharge to nearest open drain.
 5. Provide flexible connections to coils, pumps and other equipment so as to eliminate undue strains in piping and equipment.
 6. Install condensate-drain lines for each air-handling unit with pitch of 1/4 inch per foot in the direction of flow.
 - a. Run drain lines to nearest open drain.
 - b. Do not exceed 400 feet maximum length of pipe between anchor and expansion joint or 90-degree offset.
 7. Do not support embedded pipe from reinforcing bars with metallic means.
- G. Expansion-Joint Installation:
 1. Field set expansion joints for position corresponding to ambient temperature at time of installation.
 2. Setting based on manufacturer's calibration data furnished with expansion joints.
 3. Do not use corrugated-bellows expansion joints where exposed in train tunnels.
 4. Install ball joints in accordance with approved published recommendations of manufacturer.
 5. Do not use shims or steel spacers.
- H. Pipe Anchors:
 1. Securely anchor piping where shown and where necessary for proper installation to force pipe expansion in proper direction.
- I. Expansion-Bolt Anchors:
 1. Drill holes and install expansion-bolt anchors as recommended by anchor-bolt manufacturer. Do not locate less than eight inches from concrete edge.
- J. Pipe Sleeves:
 1. Exterior walls:
 - a. Install as shown.
 - b. Test cathodically protected pipe
 2. Interior walls:
 - a. Install as shown. Seal to maintain integrity of walls.
- K. Plumbing-Fixture and Equipment Connections (NOT USED):
- L. Drains (NOT USED):
 1. Install floor drains with traps.

- M. Air-Separator Installation:
 - 1. Install air separator on suction side of chilled-water pump and as near to pump as practicable.
 - 2. Install dead-level in both directions and support from structure so that pipe can be removed without moving air separator.
 - 3. Install two-inch drain line, equipped with gate valve and union, from blowdown connection to nearest drain.
- N. Attachments to Prestressed-Concrete Girders:
 - 1. Attach pipes and similar items to prestressed girders by welding to embedded plates or bolting to embedded fittings. Drilling into prestressed girders is prohibited, except as shown.
- O. Refrigeration Copper Tubing Installation (NOT USED):
- P. Bonding: In accordance with Section 16060, and with the following additional requirements:
 - 1. Bond mechanical joints and fittings, including valves, by exothermic-welding method.
 - 2. Make welds in accordance with recommendations of the manufacturer. Clean and coat with coal tar epoxy.
 - 3. Bond pipe using bonding strap welded to each side of joint not less than six inches from joint. Allow sufficient slack in conductor for expansion of pipe.
- Q. Firestopping:
 - 1. Pipe penetration through fire rated partitions to be sealed with approved fireproof sealant.

3.02 PROTECTION OF PIPING AND EQUIPMENT:

- A. Protect pipe, openings, valves and fixtures from dirt, foreign objects and damage during construction.
- B. Replace damaged piping, valves, fixtures and appurtenances.
- C. Prior to testing, flush piping with chemically treated water until systems are clean and free of scale, slag, dirt, oil, grease and other foreign material.
- D. Hand-clean expansion joints and strainers.
- E. Coal-Tar Epoxy Coating for Protection of Ferrous Piping

3.03 FIELD QUALITY CONTROL:

- A. Water-Pressure Testing:
 - 1. Prior to burial or concealment, test affected piping in presence of the Engineer using specified procedures.
 - 2. Test entire piping systems and test until found leak-free in presence of and to satisfaction of the Engineer.
 - 3. Notify the Authority at least 36 hours in advance of making tests.
 - 4. Test piping at following pressures:
 - a. Chilled-water and condenser-water piping embedded or otherwise inaccessible: 400-psi minimum.
 - b. Chilled-water and condenser-water piping, exposed and accessible: 150 psi or 1-1/2 times maximum working pressure, whichever is greater, at lowest point in system.

B. Test Procedures:

1. Chilled-water and condenser-water piping embedded or otherwise inaccessible:
 - a. Avoid excessive pressure on safety devices and mechanical seals.
 - b. Fill entire system with water and vent air from system at least 24 hours before test pressure is applied.
 - c. Apply test pressure when water and average ambient temperatures are approximately equal and constant.
 - d. Maintain test pressure for minimum of six hours without drop after force pump has been disconnected.
 - e. Visually inspect joints while pipe is under test pressure.

C. Control-air piping:

1. Test main air piping at minimum of 150 psi and maintain pressure for one hour without pumping.
 - a. Test low-pressure air piping at minimum of 30 psi and maintain pressure for one hour without pumping.
 - b. Correct leaks by remaking joints.

D. Repair of Leaks:

1. Do not repair by mechanical caulking leaks in threads or welds occurring while pipeline is under test or in service.
2. Introduction into piping system of material intended to stop leakage is prohibited.
3. Repair leaks in threaded piping by breaking joint, cutting new threads on pipe and installing new pipe fitting. Remove defective welds by chipping or gas gouging from one or both sides of joint.
 - a. Reweld chipped-out places.
 - b. When base metals of fillet-weld are cut back or throat of weld is less than specified, repair defect by adding additional weld metal.

3.05 FIELD PAINTING:

- A. Paint exposed soil and waste pipe lines in accordance with Section 09920.

* * *

END OF SECTION

SECTION 15625A

WATER COOLED CENTRIFUGAL CHILLERS

PART 1. GENERAL

1.01 SUMMARY

- A. Section includes design, performance criteria, refrigerants, controls, and installation requirements for water-cooled centrifugal chillers.
- B. Related Work Specified Elsewhere:
 - 1. Concrete pads: Sections 03100 and 03300.
 - 2. Piping systems: Section 15205.
 - 3. Insulation: Section 15080.
 - 4. Vibration isolation: Section 15070.
 - 5. Conduit, raceways and cabinets: Section 16130.
 - 6. Wire, cable and busways: Section 16120.

1.02 REFERENCES

- A. Comply with the following codes and standards:
 - 1. AHRI 550/590
 - 2. AHRI 575
 - 3. NEC
 - 4. ANSI/ASHRAE 15
 - 5. OSHA as adopted by the State
 - 6. ETL • ASME Section VIII

1.03 SUBMITTALS

- A. Submittals shall include the following:
 - 1. Dimensioned plan and elevation view, including required clearances, and location of all field piping and electrical connections.
 - 2. Summaries of all auxiliary utility requirements such as: electricity, water, air, etc. Summary shall indicate quality and quantity of each required utility.
 - 3. Diagram of control system indicating points for field interface and field connection. Diagram shall fully depict field and factory wiring.
 - 4. Manufacturer's certified performance data at full load plus IPLV or NPLV.
 - 5. Installation and Operating Manuals.

1.04 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with the codes and standards in Section 1.2.
- B. Chiller manufacturer plant shall be ISO Certified.
- C. The chiller shall be tested to job conditions at the manufacturer's plant.

1.05 DELIVERY AND HANDLING

- A. The unit shall be delivered to the job site completely assembled and charged with refrigerant R134a (pumped down into condenser) and ready for field knockdown, as determined by the installing contractor.
- B. Comply with the manufacturer's instructions for rigging and transporting units. Leave protective covers in place until installation.

PART 2. PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Basis of Design - Magnitude Model WMC, including the standard product features and all special features required per the plans and specifications.
- B. Equal Products - Equipment manufactured by others may be acceptable as an equal. Equipment proposed "as equal", must meet the specifications including all architectural, mechanical, electrical, and structural details, all scheduled performance and the job design, plans and specifications.

2.02 UNIT DESCRIPTION

- A. Provide and install as shown on the plans a factory assembled, charged, and tested water-cooled packaged centrifugal chiller. Chillers shall have no more than two oil-free, magnetic bearing, semi-hermetic centrifugal compressors (no exceptions). Each compressor shall have an integrated variable-frequency drive operating in concert with inlet guide vanes for optimized full and part load efficiency. On two-compressor units, the evaporator and condenser refrigerant sides and the expansion valve shall be common and the chiller shall be capable of running on one compressor with the other compressor or any of its auxiliaries inoperable or removed.
- B. Each chiller shall be factory run-tested under load conditions for a minimum of one hour on an AHRI qualified test stand with evaporator and condenser water flow at job conditions (excluding glycol applications). Operating controls shall be adjusted and checked. The refrigerant charge shall be adjusted for optimum operation and recorded on the unit nameplate. Units operating with 50-Hz power shall be tested with a 50-Hz power supply. Any deviation in performance or operation shall be remedied prior to shipment and the unit retested if necessary to confirm repairs or adjustments. Manufacturer shall supply a certificate of completion of a successful run-test upon request.

2.03 DESIGN REQUIREMENTS

- A. General: Provide a complete water-cooled, semi-hermetic oil-free centrifugal compressor water chiller as specified herein. The unit shall be provided according to standards indicated in Section 1.2. In general, unit shall consist of one or two magnetic bearing, completely oil-free centrifugal compressors, refrigerant, condenser and evaporator, and control systems including integrated variable frequency drive, operating controls and equipment protection controls. Chillers shall be designed to operate within an ambient temperature range of 40°F to 104°F with a maximum humidity of 95% (non-condensing) and shall be charged with refrigerant HFC-134a.
- B. The entire chiller system, including all pressure vessels, shall remain above atmospheric pressure during all operating conditions and during shut down to ensure that non-condensables and moisture do not contaminate the refrigerant and chiller system.
- C. Performance: Refer to chiller performance rating.

2.04 CHILLER COMPONENTS

- A. Compressors:
 - 1. The unit shall utilize magnetic bearing, oil-free, semi-hermetic centrifugal compressors. The levitated shaft position shall be digitally controlled and shall be monitored by X-axis position sensor, Y-axis position sensor, and Z-axis position sensor. The compressor drive train shall be capable of

coming to a controlled, safe stop in the event of a power failure by diverting stored power to the magnetic bearing controls system.

2. The motor shall be of the semi-hermetic type, of sufficient size to efficiently fulfill compressor horsepower requirements. It shall be liquid refrigerant cooled with internal thermal sensing devices in the stator windings. The motor shall be compatible with variable frequency drive operation.
3. The chiller shall be equipped with an integrated variable frequency drive (VFD) to automatically regulate compressor speed in response to cooling load and the compressor pressure lift requirement. Movable inlet guide vanes and variable compressor speed acting together, shall provide unloading. The chiller controls shall coordinate compressor speed and guide vane position to optimize chiller efficiency.
4. Each compressor circuit shall be equipped with a line reactor to help protect against incoming power surges and help reduce harmonic distortion.

B. Evaporator and Condenser:

1. The evaporator and condenser shall be separate vessels of the shell-and-tube type, designed, constructed, tested and stamped according to the requirements of the ASME Code, Section VIII. Regardless of the operating pressure, the refrigerant side of each vessel will bear the ASME stamp indicating compliance with the code and indicating a test pressure of 1.1 times the working pressure, but not less than 100 psig. The tubes shall be individually replaceable and secured to the intermediate supports without rolling or expanding to facilitate replacement if required.
 - a. The evaporator shall be flooded type with 0.035 in. wall copper internally and externally enhanced tubes rolled into carbon steel tubesheets. The water side shall be designed for a minimum of 150 psig. The refrigerant side shall be designed for a minimum of 200 psi. Provide intermediate tube supports at a maximum of 24 inch spacing. The heads shall be epoxy-coated steel. Water connections shall be grooved suitable for Victaulic couplings. The evaporator shall have dished heads with valved drain and vent connections. The evaporator shall have right-hand inlet connections when looking at the unit control panel.
 - b. The condenser shall have 0.035 in. wall copper internally and externally enhanced tubes rolled into carbon steel. Water connections shall be grooved suitable for Victaulic couplings. The water side shall be designed for a minimum of 150 psig. The refrigerant side shall be designed for a minimum of 200 psi. Provide intermediate tube supports at a maximum of 24 inch spacing. The condenser shall have dished heads with valved drain and vent connections. The heads shall be epoxy-coated steel. The condenser shall have right-hand connections when looking at the unit control panel.
 - c. Provide sufficient isolation valves and condenser volume to hold the full unit refrigerant charge the condenser at 90°F in accordance with ANSIASHRAE 15.A during servicing or provide a separate pumpout system and storage tank sufficient to hold the charge of the largest unit being furnished.
 - d. An electronic expansion valve shall control refrigerant flow to the evaporator. Fixed orifice devices or float controls with hot gas bypass are not acceptable because of inefficient control at low load conditions. The liquid line shall have moisture indicating sight glass.
 - e. Re-seating type spring loaded pressure relief valves according to ASHRAE-15 safety code shall be furnished. The evaporator shall be provided with single or multiple valves. The condenser shall be provided with dual relief valves equipped with a transfer valve so one relief valve can be removed for testing or replacement without loss of refrigerant or removal of refrigerant from the condenser. Rupture disks are not acceptable.
 - f. The evaporator, including water heads, suction line, and any other component or part of a component subject to condensing moisture shall be insulated with UL recognized 1 ½ inch closed cell insulation. All joints and seams shall be carefully sealed to form a vapor barrier.
 - g. Provide factory-mounted and wired, thermal-dispersion water flow switches on each vessel to prevent unit operation with no or low water flow. Paddle and pressure differential type switches are not acceptable due to high rates of failure and false indications from these types of flow indicators.

C. Vibration Isolation

1. Provide neoprene waffle-type vibration isolators for each corner of the unit.

D. Power Connections

1. Power connection shall be single point to a factory-mounted disconnect switch.

E. Chiller Control

1. The unit shall have a microprocessor-based control system consisting of a 15-inch VGA touch-screen operator interface and a unit controller.
2. The touch-screen shall display the unit operating parameters, accept set point changes (multi-level password protected) and be capable of resetting faults and alarms. The following parameters shall be displayed on the home screen and also as trend curves on the trend screen:
 - a. Entering and leaving chilled water temperatures
 - b. Entering and leaving condenser water temperatures
 - c. Evaporator saturated refrigerant pressure
 - d. Condenser saturated refrigerant pressure
 - e. Percent of 100% speed (per compressor)
 - f. % of rated load amps for entire unit
3. In addition to the trended items above, all other important real-time operating parameters shall also be shown on the touch-screen. These items shall be displayed on a chiller graphic showing each component. At a minimum, the following critical areas must be monitored:
 - a. Compressor actual speed, maximum speed, percent speed
 - b. Liquid line temperature
 - c. Chilled water setpoint
 - d. Compressor and unit state and input and output digital and analog values
4. A fault history shall be displayed using an easy to decipher, color coded set of messages that are date and time stamped. Time interval scale shall be user selectable as 20 mins, 2 hours, or 8 hours. The alarm history shall be downloadable from the unit's USB port. An operating and maintenance manual specific for the unit shall be viewable on the screen.
5. All setpoints shall be viewable and changeable (multi-level password protected) on the touch screen and include setpoint description and range of set values.
6. Automatic corrective action to reduce unnecessary cycling shall be accomplished through preemptive control of low evaporator or high discharge pressure conditions to keep the unit operating through abnormal transient conditions.
7. The chiller shall be capable of cycling and loading up to three other similar chillers through a local network and also automatic control of evaporator and condenser pumps (primary and standby), up to 3 stages of cooling tower fan cycling control and a tower modulating bypass valve or cooling tower fan variable frequency drives.
8. The factory mounted controller(s) shall support operation on a Modbus® network via one of the data link / physical layers listed below as specified by the successful Building Automation System (BMS) supplier.
 - a. Modbus
9. The information communicated between the BMS and the factory mounted unit controllers shall include the reading and writing of data to allow unit monitoring, control and alarm notification as specified in the unit sequence of operation and the unit points list.
10. The factory supplied VFD and controls should include the following:
 - a. High short circuit panel rating of 35 kA (standard) with a field-supplied matching disconnect

- switch
 - b. Phase loss protection
 - c. Under/over voltage protection
11. Energy saving software logic shall at a minimum offer the following
- a. User programmable compressor soft loading
 - b. Chilled water reset
 - c. Demand limit control
 - d. Staging options lead lag between multiple compressors on a single chiller or up to two other similar chillers.
 - e. Plotting of historic trends for optimizing efficiency

PART 3. EXECUTION

3.01 INSTALLATION

- A. Installing contractor to:
- 1. Install per manufacturer's requirements, shop drawings, and contract documents.
 - 2. Adjust chiller alignment on foundations, or subbases as called for on drawings.
 - 3. Arrange piping to allow for dismantling to permit head removal and tube cleaning.
 - 4. Coordinate electrical installation with electrical contractor.
 - 5. Coordinate controls with control contractor.
 - 6. Provide all material required for a fully operational and functional chiller.
 - 7. Install unit in a dry indoor location consistent with NEMA 1 design.

3.02 START-UP

- A. Factory Start-Up Services: Provide for as long a time as is necessary to ensure proper operation of the unit, but in no case for less than two full working days. During the period of start-up, the start-up technician shall instruct the owner's representative in proper care and operation of the unit.

* * *

END OF SECTION

SECTION 15635

REFRIGERANT MONITORING EQUIPMENT

PART 1. GENERAL

1.01 SUMMARY

- A. This Section includes refrigerant monitors, alarms, and breathing apparatus.

1.02 DEFINITIONS

1. CMOS: Ceramic metal-oxide semiconductor.
2. HFC: Hydrofluorocarbon.
3. HCFC: Hydrochlorofluorocarbon.
4. IR: Infrared.
5. LED: Light-emitting diode.
6. ppm: Parts per million.

1.03 SUBMITTALS

1. Shop Drawings: For each type of refrigerant monitor; include refrigerant ppm range, temperature range, alarm outputs, readout range, furnished specialties, installation requirements, and power consumption
 - a. Wiring Diagrams: Power, signal, and control wiring.
2. Coordination Drawings: Include machinery room layout showing location of monitoring devices in relation to refrigerant equipment.
3. Product Certificates: For monitoring devices signed by product manufacturer.
4. Operation and Maintenance Data: For refrigerant monitoring equipment to include in emergency, operation, and maintenance manuals.

1.04 QUALITY ASSURANCE

1. ASHRAE: Monitoring system shall comply with ASHRAE 15.

PART 2. PRODUCTS

2.01 MANUFACTURERS

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Refrigerant Monitoring Equipment:
 - a. Genesis International Inc..

2.02 FUNCTIONAL DESCRIPTION OF REFRIGERANT MONITORING SYSTEM

- A. On leak detection by refrigerant sensor(s), the system shall perform the following
1. Activate machinery room ventilation.
 2. Activate audio and visual alarm inside and outside machinery room.
 3. Shut down combustion process where combustion equipment is employed.
 4. Notify Building Automation System of alarm condition.

2.03 REFRIGERANT MONITOR

- A. Description: CMOS or IR sensor shall continuously measure and display the specific gas concentration and shall be capable of indicating, alarming, and shutting down equipment, and automatically activating ventilation system.
- B. Performance Requirements:
 - 1. Refrigerant to Be Monitored: HFC-134a.
 - 2. Refrigerant Concentration: 0 to 1000 ppm.
 - 3. Accuracy: 1 ppm.
 - 4. Linearity: 0 to 500 ppm; linear.
 - 5. Sensitivity: 1 ppm.
 - 6. Resolution: 1 ppm.
 - 7. Operating Temperature: 41 to 104 deg F (5 to 40 deg C).
 - 8. Response Time: 90 percent of a step change in 4 minutes.
 - 9. Relatively Humidity: 20 to 95 percent, non-condensing over the operating temperature range.
- C. Operating Requirements:
 - 1. Maximum Power Input: 120-V ac; 60 Hz, 30 W.
 - 2. Alarm Relays: 3 relays at 5- to 8-A resistive load (dry contacts). See the drawings.
 - 3. Alarm Set Points: Displayed on front of meter.
 - 4. Audible Output: Sonic alert at 75 to 80 dB at 60 inches (1525 mm).
 - 5. Analog Output: 0- to 10-V dc or 4- to 20-mA current sourcing.
 - 6. Serial Output Type: RS 232.
- D. Display: 10-character, alphanumeric, vacuum-fluorescent indicating lights for each alarm set point; standard alarm; acknowledge switch and test switch mounted on front panel; and alarm status LEDs and service fault LEDs.
 - 1. Enclosure: NEMA 250, type as required for ambient condition.
- E. Alarm Output: Indicating light flashes and horn sounds.
 - 1. Unit-mounting device with single-light beacon. Field-adjustable alarm set points.
- F. Calibration: Factory calibrated.

2.04 SOURCE QUALITY CONTROL

- A. Refrigerant Monitor: Factory tested and certified.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine chiller layout for proper location of monitoring devices.
- B. Verify refrigerant contained in chiller(s) to ensure compatibility of refrigerant monitor.
- C. Examine machinery room ventilation system to verify its operation with refrigerant monitor(s).

3.02 INSTALLATION

- A. Install refrigerant monitoring equipment level and plumb.
- B. Install labels and nameplates to identify monitoring devices and SCBA components according to Section 15075

3.03 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
 - 1. Inspect field-assembled components, equipment installation, and electrical connections for compliance with requirements.

2. Test and adjust controls and safeties.
 3. Test Reports: Prepare a written report to record the following:
 - a. Test procedures used.
 - b. Test results that comply with requirements.
 - c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.04 ADJUSTING

- A. Adjust alarm set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.05 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain refrigerant monitoring devices.
- B. Training: Provide a "how-to-use" SCBA video that details exact operating procedures of equipment.

* * *

END OF SECTION

SECTION 15733A

AIR CONDITIONING UNITS - CHILLED WATER COOLED

PART 1. GENERAL

1.01 DESCRIPTION:

- A. This section specifies providing factory-built air-conditioning units with cabinet-type fan sections and coil sections.
- B. Related Work Specified Elsewhere:
 - 1. Piping systems: Section 15205.
 - 2. Vibration isolation: Section 15070.
 - 3. Control equipment: Section 15900.
 - 4. Raceways, boxes and cabinets: Section 16130.
 - 5. Wire, cable and busways: Section 16120.
 - 6. Motors: Section 16225.
 - 7. Motor starters and control centers: Section 16425.

1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
 - 1. Comply with codes and regulations of the jurisdictional authorities.
 - 2. NFPA: 90A.
 - 3. ARI: 430.
- B. Qualifications of Manufacturer:
 - 1. Furnish air-conditioning units which are the products of a manufacturer who is a member of AMCA.

1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
 - 1. Shop Drawings.
 - 2. Operation and Maintenance Manuals.

1.04 JOB CONDITIONS:

- A. Safety Requirements:
 - 1. Properly guard belts, pulleys, chains, gears, couplings, projecting set screws, keys and other rotating parts to prevent danger to personnel.

PART 2. PRODUCTS

2.01 PRODUCTS AND MATERIALS:

- A. General Requirements:
 - 1. In design and purchase of equipment, provide for interchangeability of items of piping equipment, subassemblies, parts, motors, starters and relays.
 - 2. Units shall be tested in accordance with ARI 430 and ARI 260.
 - 3. Units shall comply with NFPA 90A and be UL listed in the U.S.
 - 4. Air handlers shall consist of a hydronic coil, drain pan, and centrifugal fan with motor and drive

mounted in a common cabinet.

5. Air handlers shall have knockouts in all four corners for installing the unit suspended from the ceiling with threaded rods.

B. Casings

1. Casings shall be constructed of heavy-gauge galvanized steel, insulated with one-inch, 1-1/2 lb density fiberglass fire resistant and odorless glass fiber material to provide thermal and acoustical insulation.
2. Fan housing sides shall be directly attached to the air handler top and bottom panels strengthening the entire unit assembly.
3. Coil access panels are to be located on both sides of the air handler and allow easy removal of the internal coils and drain pan.
4. Main access panels shall provide generous access to the fan, motor and drive from both sides of the air handler

C. Fans

1. Fans shall be forward curved, centrifugal blower type equipped with heavy-duty adjustable speed V-belt drive.
2. The fan shaft shall be supported by heavy-duty, permanently sealed ball bearings.
3. Fans shall be dynamically balanced.

D. Hydronic Coils

1. Cooling coils shall be four- or six-row, chilled water.
2. All hydronic coils are 12 fins per inch. All hydronic coils shall use highly efficient aluminum fins, mechanically bonded to seamless copper tubes
3. All coils shall be factory tested with 450 psi air under water.
4. Maximum standard operating conditions are: 300 psig, 200°F. Sweat type connections are standard.

E. Drain Pan

1. The drain pan is noncorrosive and double-sloped to allow condensate drainage.
2. The drainpan construction shall be polymer.
3. Coils mount above the drain pan—not in the drain pan—thus allowing the drain pan to be fully inspected and cleaned
4. The drain pan shall be removable for cleaning.
5. The polymer drain pan connections are unthreaded 3/4" schedule 40 PVC for solvent bonding.

F. Filters

1. Unit shall have angle filter rack sized for less than 300 feet per minute at nominal airflow.
2. Filters shall be two-inch MERV 8

G. Motors

1. Three-phase motors shall be 460 voltage operation. All motors shall have a plus or minus 10 percent voltage utilization range. All standard motors shall be open drip-proof with permanently sealed ball bearings, internal current and thermal overload protection, a minimum 1.15 service factor and 56 frame resilient bases. Motors shall be factory-installed and wired to the air handler junction box

H. Piping package

1. Chilled water piping shall consist of solenoid operated two-way control valve, strainer, balancing valve, and ball isolation valves.
2. The maximum entering fluid temperature to the water valves is 200°F.
3. All chilled water piping and accessories shall be insulated.

I. Control Interface

1. Air handler shall be equipped a control interface is intended to be used with a field-supplied, low-voltage thermostat.
2. The control box shall contain a line voltage to 24-volt transformer; a three-pole contactor for the fan and a contactor for the solenoid operated valve.

J. Nameplates

1. Securely attached plate to each air-conditioning unit showing manufacturer's name, model number and serial number.

PART 3. EXECUTION

3.01 INSTALLATION:

- A. Fit equipment and appurtenances within space provided and make readily serviceable.
- B. Provide foundations, platforms and hangers necessary for proper installation of equipment.
- C. Install units on vibration isolators as specified in Section 15070.
- D. Electrical connections: Sections 16130 and 16120.
- E. Condensate piping: Section 15205.
- F. After installation, adjust fans to operate without noticeable vibration.
- G. Arrange belt guards to permit oiling, testing and using tachometer with guards in place.

* * *

END OF SECTION

SECTION 15815

METAL DUCTS

PART 1 - GENERAL

A. DESCRIPTION:

- A. This Section includes metal ducts for supply, return, outside, and exhaust air-distribution systems in pressure classes from (minus 500 to plus 2500 Pa) minus 2- to plus 10-inch wg. Metal ducts include the following:

1. Rectangular ducts and fittings.

- B. Related Sections include the following:

1. Division 15 Section "Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.2 SUBMITTALS:

- A. Shop Drawings: CAD-generated and drawn to (1:50) 1/4 inch equals 1 foot scale. Show fabrication and installation details for metal ducts.

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Duct layout indicating sizes and pressure classes.
3. Elevations of top and bottom of ducts.
4. Fittings.
5. Reinforcement and spacing.
6. Seam and joint construction.
7. Penetrations through fire-rated and other partitions.
8. Equipment installation based on equipment being used on Project.
9. Duct accessories, including access doors and panels.

- B. Welding certificates.

- C. Field quality-control test reports.

1.3 QUALITY ASSURANCE:

- A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- B. NFPA Compliance:
 - 1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
 - 2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS:

- A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 (Z275K) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.
- D. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.2 SEALANT MATERIALS:

- A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.
- B. Joint and Seam Tape: 2 inches (50 mm) wide; glass-fiber-reinforced fabric
- C. Tape Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
- D. Solvent-Based Joint and Seam Sealant: One-part, nonsag, solvent-release-curing,

polymerized butyl sealant formulated with a minimum of 75 percent solids.

- E. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
- F. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.3 HANGERS AND SUPPORTS:

- A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
 - 2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
- B. Hanger Materials: Galvanized sheet steel or threaded steel rod.
 - 1. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
 - 2. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.
- C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2.4 RECTANGULAR DUCT FABRICATION:

- A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
 - 1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
 - 2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

- B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.
 - 1. Manufacturers:
 - a) Ductmate Industries, Inc.
 - b) Nexus Inc.
 - c) Ward Industries, Inc.
- C. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches (480 mm) and larger and 0.0359 inch (0.9 mm) thick or less, with more than 10 sq. ft. (0.93 sq. m) of nonbraced panel area unless ducts are lined.

2.5 APPLICATION OF LINER IN RECTANGULAR DUCTS:

- A. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
- B. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
- C. Butt transverse joints without gaps and coat joint with adhesive.
- D. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
- E. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.
- F. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm (12.7 m/s).
- G. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) longitudinally.
- H. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 - 1. Fan discharges.

2. Intervals of lined duct preceding unlined duct.
 3. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm (12.7 m/s) or where indicated.
- I. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
 1. Sheet Metal Inner Duct Perforations: 3/32-inch (2.4-mm) diameter, with an overall open area of 23 percent.
 - J. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

PART 3 - EXECUTION

3.1 DUCT APPLICATIONS:

- A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:
 1. Supply and return Ducts: 3-inch (750 Pa) wg positive or negative.
- B. All ducts shall be galvanized steel.

3.2 DUCT INSTALLATION:

- A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
- B. Install ducts with fewest possible joints.
- C. Install fabricated fittings for changes in directions, size, and shape and for connections.
- D. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches (300 mm), with a minimum of 3 screws in each coupling.
- E. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and

perpendicular to building lines; avoid diagonal runs.

- F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- G. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.
- H. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.
- I. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.
- J. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches (38 mm).
- K. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Division 15 Section "Duct Accessories." Firestopping materials and installation methods are specified in Division 7 Section "Through-Penetration Firestop Svstems."

3.3 SEAM AND JOINT SEALING:

- A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated. All new ductwork shall be sealed SMACNA Seal Class "A".
 - 1. For pressure classes lower than 2-inch (500 Pa) wg, seal transverse joints.
- B. Seal ducts before external insulation is applied.

3.4 HANGING AND SUPPORTING:

- A. Support horizontal ducts within 24 inches (600 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.
- B. Support vertical ducts at maximum intervals of 16 feet (5 m) and at each floor.
- C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.
- D. Install concrete inserts before placing concrete.

- E. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 1. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.

3.5 CONNECTIONS:

- A. Make connections to equipment with flexible connectors according to Division 15 Section "Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 FIELD QUALITY CONTROL:

- A. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports:
 - 1. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 - 2. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
 - 3. Maximum Allowable Leakage: Comply with requirements for Leakage Class 3 for round and flat-oval ducts, Leakage Class 12 for rectangular ducts in pressure classes lower than and equal to 2-inch (500 Pa) wg (both positive and negative pressures), and Leakage Class 6 for pressure classes from 2- to 10-inch (500 to 2500 Pa) wg.
 - 4. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

3.7 CLEANING NEW SYSTEMS:

- A. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.
- B. Use service openings, as required, for physical and mechanical entry and for inspection.
 - 1. Create other openings to comply with duct standards.
 - 2. Disconnect flexible ducts as needed for cleaning and inspection.

3. Remove and reinstall ceiling sections to gain access during the cleaning process.
- C. Vent vacuuming system to the outside. Include filtration to contain debris removed from HVAC systems, and locate exhaust down wind and away from air intakes and other points of entry into building.
- D. Clean the following metal duct systems by removing surface contaminants and deposits:
1. Air outlets and inlets (registers, grilles, and diffusers).
 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 4. Coils and related components.
 5. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
 6. Supply-air ducts, dampers, actuators, and turning vanes.
- E. Mechanical Cleaning Methodology:
1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
 4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet.
 5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
- F. Cleanliness Verification:

1. Visually inspect metal ducts for contaminants.
2. Where contaminants are discovered, re-clean and reinspect ducts.

3.8 CLEANING EXISTING SYSTEMS:

- A. Use service openings, as required, for physical and mechanical entry and for inspection.
 1. Use existing service openings where possible.
 2. Create other openings to comply with duct standards.
 3. Disconnect flexible ducts as needed for cleaning and inspection.
 4. Reseal rigid fiberglass duct systems according to NAIMA recommended practices.
 5. Remove and reinstall ceiling sections to gain access during the cleaning process.
- B. Mark position of dampers and air-directional mechanical devices before cleaning, and restore to their marked position on completion.
- C. Particulate Collection and Odor Control:
 1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron size (or larger) particles.
 2. When venting vacuuming system to the outside, use filtration to contain debris removed from HVAC system, and locate exhaust down wind and away from air intakes and other points of entry into building.
- D. Clean the following metal duct systems by removing surface contaminants and deposits:
 1. Air outlets and inlets (registers, grilles, and diffusers).
 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 4. Coils and related components.

5. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
 6. Supply-air ducts, dampers, actuators, and turning vanes.
 7. Dedicated exhaust and ventilation components and makeup air systems.
- E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning.

Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.

3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide operative drainage system for washdown procedures.
7. Biocidal Agents and Coatings: Apply biocidal agents if fungus is present. Apply biocidal agents according to manufacturer's written instructions after removal of surface deposits and debris.

F. Cleanliness Verification:

1. Verify cleanliness after mechanical cleaning and before application of treatment, including biocidal agents and protective coatings.
2. Visually inspect metal ducts for contaminants.
3. Where contaminants are discovered, re-clean and reinspect ducts.

G. Gravimetric Analysis: At discretion and expense of Owner, sections of metal duct system,

chosen randomly by Owner, may be tested for cleanliness according to NADCA vacuum test gravimetric analysis.

1. If analysis determines that levels of debris are equal to or lower than suitable levels, system shall have passed cleanliness verification.
2. If analysis determines that levels of debris exceed suitable levels, system cleanliness verification will have failed and metal duct system shall be

H. Verification of Coil Cleaning: Cleaning must restore coil pressure drop to within 10 percent of pressure drop measured when coil was first installed. If original pressure drop is not known, coil will be considered clean only if it is free of foreign matter and chemical residue, based on thorough visual inspection.

* * *

END OF SECTION

SECTION 15820

DUCT ACCESSORIES

PART 1 – GENERAL

1.1 DESCRIPTION:

- A. This Section includes the following:
 - 1. Backdraft dampers.
 - 2. Volume dampers.
 - 3. Fire dampers.
 - 4. Turning vanes.
 - 5. Duct-mounting access doors.
 - 6. Flexible connectors.
 - 7. Duct accessory hardware.
- B. Related Sections include the following:
 - 1. Division 15 Section “Control Equipment” for electric damper actuators.

1.2 SUBMITTALS:

- A. Product Data: For the following:
 - 1. Backdraft dampers.
 - 2. Volume dampers.
 - 3. Fire dampers.
 - 4. Turning vanes.
 - 5. Duct-mounting access doors.
 - 6. Flexible connectors.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Special fittings.
 - 2. Manual-volume damper installations.
 - 3. Fire-damper, installations, including sleeves and duct-mounting access doors.
 - 4. Wiring Diagrams: Power, signal, and control wiring.

1.3 QUALITY ASSURANCE:

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

1.4 EXTRA MATERIALS:

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 — PRODUCTS

2.1 SHEET METAL MATERIALS:

- A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.
- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 (Z275) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. Aluminum Sheets: ASTM B 209 (ASTM B 209M), alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- D. Extruded Aluminum: ASTM B 221 (ASTM B 221M), alloy 6063, temper T6.
- E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.2 VOLUME DAMPERS:

- A. Manufacturers:
 - 1. Air Balance, Inc.
 - 2. METALAIR, Inc.
 - 3. Nailor Industries Inc.
 - 4. Penn Ventilation Company, Inc.
 - 5. Ruskin Company.
- B. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.

1. Pressure Classes of 3-Inch wg (750 Pa) or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.
- C. Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, standard leakage rating, and suitable for horizontal or vertical applications.
1. Steel Frames: Hat-shaped, galvanized sheet steel channels, minimum of 0.064 inch (1.62 mm) thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
 2. Roll-Formed Steel Blades: 0.064-inch (1.62-mm) thick, galvanized sheet steel.
 3. Roll-Formed Aluminum Blades: 0.10-inch (2.5-mm) thick aluminum sheet.
 4. Extruded-Aluminum Blades: 0.050-inch (1.2-mm) thick extruded aluminum.
 5. Blade Axles: Galvanized steel.
 6. Tie Bars and Brackets: Galvanized steel.
- D. Jackshaft: 1-inch (25-mm) diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.
- E. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

2.3 FIRE/SMOKE DAMPERS:

- A. Manufacturers:
1. Air Balance, Inc.
 2. CESCO Products.
 3. Greenheck.
 4. METALAIR, Inc.
 5. Nailor Industries Inc.
 6. Penn Ventilation Company, Inc.
 7. Ruskin Company.
- B. Fire/Smoke dampers shall be labeled according to UL 555.
- C. Fire Rating: 1-1/2 hours.

- D. Frame: Curtain type with blades inside airstream; fabricated with roll-formed, 0.034-inch(0.85-mm) thick galvanized steel; with mitered and interlocking corners.
- E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
 - 1. Minimum Thickness: 0.052 or 0.138 inch (1.3 or 3.5 mm) thick as indicated and of length to suit application.
 - 2. Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.
- F. Mounting Orientation: Vertical or horizontal as indicated.
- G. Blades: Roll-formed, interlocking, 0.034-inch (0.85-mm) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch (0.85-mm) thick, galvanized-steel blade connectors.
- H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- I. Fusible Links: Replaceable, 165 deg F (74 deg C) rated.

2.4 TURNING VANES:

- A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards—Metal and flexible" for vanes and vane runners. Vane runners shall automatically align vanes.
- B. Manufactured Turning Vanes: Fabricate 1-1/2-inch (38-mm) wide, single-vane, curved blades of galvanized sheet steel set ¾ inch (19 mm) o.c.; support with bars perpendicular to blades set 2 inches (50 mm) o.c.; and set into vane runners suitable for duct mounting.
- C. Manufacturers:
 - a. Ductmate Industries, Inc.
 - b. Duro Dyne Corp.
 - c. METALAIRE, Inc.
 - d. Ward Industries, Inc.

2.5 DUCT-MOUNTING ACCESS DOORS:

- A. General Description: Fabricate doors airtight and suitable for duct pressure class.
- B. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated. Include 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam latches.
 - 1. Manufacturers:

- a. CESCO Products.
 - b. Ductmate Industries, Inc.
 - c. Flexmaster U.S.A., Inc.
 - d. Greenheck.
 - e. Nailor Industries Inc.
- 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
- 3. Provide number of hinges and locks as follows:
 - a. Less Than 12 Inches (300 mm) Square: Secure with two sash locks.
 - b. Up to 18 Inches (450 mm) Square: Two hinges and two sash locks.
 - c. Up to 24 by 48 Inches (600 by 1200 mm): Three hinges and two compression latches with outside and inside handles.
 - d. Sizes 24 by 48 Inches (600 by 1200 mm) and Larger: One additional hinge.
- C. Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with insulation fill and 1-inch (25-mm) thickness. Include cam latches.
 - 1. Manufacturers:
 - a) Flexmaster U.S.A., Inc.
 - 2. Frame: Galvanized sheet steel, with spin-in notched frame.

2.6 DUCT ACCESSORY HARDWARE:

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw Cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct insulation thickness.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 — EXECUTION

3.1 APPLICATION AND INSTALLATION:

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards—Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel..

- C. Provide test holes at fan inlets and outlets and elsewhere as indicated.
- D. Install fire dampers, with fusible links, according to manufacturer's UL-approved written instructions.
- E. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.

3.2 ADJUSTING:

- A. Adjust duct accessories for proper settings.
- B. Adjust fire dampers for proper action.

* * *

END OF SECTION

SECTION 15900

HVAC INSTRUMENTATION AND CONTROLS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B.** See spec Section 15186 – Water Treatment System which is part of the Chiller Plant Monitoring System.

1.02 SUMMARY

- A.** Provide a complete Chiller Plant Monitoring and Control System integrated with Water Treatment System – Monitoring as specified and as shown in the Contract Drawings with all necessary hardware and software; programming, training, etc. in order to process the Sequence of Operation of Chiller Plant, Air-handling unit and Water Treatment Installation. The software programs specified in this Section shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer for execution.
- B.** This section includes control equipment for HVAC – Air Handling Units and other systems and components as indicated. The DDC system shall accept signals from the fire alarm system to implement the smoke management as required. The contractor shall coordinate this work with the existing fire alarm system.
- C.** In addition to other work described herein, the Automatic Temperature control work shall include working with the Testing and Balancing Contractor during his TAB operations. Work shall include, but not be limited to providing DDC controlled damper set points based on TAB requirements for both normal and smoke control mode conditions.
- D. DEFINITIONS**
 - 1.** Provide: Furnish and install complete and ready for use.
 - 2.** Install: Erect, mount and connect complete with related accessories.
 - 3.** Furnish: Purchase, procure, acquire and deliver complete with related accessories.
 - 4.** Work: Labor, materials, equipment, apparatus, controls, accessories and other items required for proper and complete installation and acceptable operation.
 - 5.** Wiring: Raceway, trunking, conduit, wire trays, fitting, wire, boxes and all related items.
 - 6.** CPU: Central Processor Unit.
 - 7.** DDCP: Direct Digital Control Panel with DDC logic, communication card for network communication and a display and keypad where indicated. Reference to Direct Digital Control Panel (DDCP) in the specification is synonymous with the identification of Temperature Control Panel (TCP) on the Contract Drawings. In this project, DDCP is referring to the Chiller Plant Monitoring Panel which also contains Water Treatment System Monitoring Controller, etc.

1.03 SYSTEM DESCRIPTION

- A. Control system consists of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on network and programmed to control mechanical systems.
- B. The Building Automation System (BMS) shall be a totally Integrated System Network (ISN) installed as a complete package of controls and instrumentation. The system shall include all computer software and hardware, operator input/output devices, sensors and controls required for complete operation. Provide all wiring, installation, supervision and labor, including calibration, adjustment, and operator training and full operating system.
- C. The system shall be a complete stand-alone building management system, modular in construction and not requiring a central computer for operation or programming. All programming shall be possible from a keypad/display on any field panel or from a remote computer. Systems which do not have keypad/display capabilities shall furnish a minimum of three (3) portable interfaces with required cables and software.
- D. The basic elements of the BMS structure shall be built up of only standard components kept in inventory by the BMS supplier. The components shall not require customizing other than setting jumpers and switches, adding firmware modules, software modules or software programming to perform required functions.
- E. The system shall be a true distributed processing system. All software control functions are to be performed by the Direct Digital Control Panel (DDCP). Each DDCP shall be a stand-alone controller, master/slave panel arrangements, except for I/O expansion cabinets, are not acceptable.
- F. The BMS shall possess a fully modular architecture, permitting expansion through the addition of more DDCP units, sensors, actuators, operator terminals. Expansion beyond this must be able to be done in additional panels or expansion modules without abandoning any initial equipment.
- G. WMATA AUTOMATED ENERGY MANAGEMENT SYSTEM (AEMS):
Not Used.

1.04 SUBMITTALS

- A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
 - 1. Each control device labeled with setting or adjustable range of control.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Schematic flow diagrams showing chillers, fans, pumps, coils, dampers, valves, and control devices. Interface with Water Treatment Monitoring System and Refrigerant Leak Monitoring System. Interface with Chiller Operating Panels (MicroTech II or approved equal).
 - 2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
 - 3. Details of control panel faces, including controls, instruments, and labeling.

4. Written description of sequence of operation.
5. Schedule of dampers including size, leakage, and flow characteristics.
6. Schedule of valves including leakage and flow characteristics.
7. Trunk cable schematic showing programmable control unit locations and trunk data conductors.
8. Listing of connected data points, including connected control unit and input device.
9. System graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations.
10. System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
- C. Software and Firmware Operational Documentation: Include the following:
 1. Software operating and upgrade manuals.
 2. Program Software Backup: On a compact disc, complete with data files.
 3. Device address list.
 4. Printout of software application and graphic screens.
 5. Software license required by and installed for DDC workstations and control systems.
- D. Software Upgrade Kit: For Owner to use in modifying software to suit future power system revisions or monitoring and control revisions.
- E. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- F. Maintenance Data: For systems to include in maintenance manuals specified in Division 1. Include the following:
 1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.
 2. Interconnection wiring diagrams with identified and numbered system components and devices.
 3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
 4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
 5. Calibration records and list of set points.
- G. Qualification Data: For firms and persons specified in "Quality Assurance" Article.
- H. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors. Revise Shop Drawings to reflect actual installation and operating sequences.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who is an authorized representative of the automatic control system manufacturer for both installation and maintenance of units required for this Project.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."
- D. Year-2000 Compliant: Computer hardware and software shall be capable of accurately processing, providing, and receiving date data from, into, and between the twentieth and twenty-first centuries, including leap-year calculations.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

1.07 COORDINATION

- A. Coordinate location of thermostats, refrigerant gas monitor sensor, water flow devices, water treatment devices, temperature sensors, and other exposed control sensors with plans and room details before

installation.

- B. Coordinate equipment with the Fire Alarm system to achieve compatibility with equipment that interfaces with that system.
- C. Coordinate supply of conditioned electrical circuits for control units and operator workstation.
- D. Coordinate equipment with the Panelboards to achieve compatibility with starter coils and annunciation devices.
- E. Coordinate equipment with the Motor-Control Centers to achieve compatibility with motor starters and annunciation device.
- F. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

1.08 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Maintenance Materials: 5 Thermostat adjusting Keys; Control Panel Keys.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance requirements for standardization of HVAC direct digital controllers and associated communication protocol to the operations control center of the WMATA Metrorail system, manufacturers offering products that may be incorporated in the Work are limited to the following:
- B. Programmable Automation Controller (PAC) – Automation Direct or approved equal.

2.02 CHILLER PLANT MONITORING CONTROL EQUIPMENT

- A. Direct Digital Control (DDC) Equipment to monitor Chiller Plant:
 - 1. DDC shall be of a solid state design using PRODUCTIVITY 3000 SYSTEM or an approved equivalent system.
 - 2. Productivity 3000 System shall be a programmable automation controller that combines the features and capabilities of a PC-based control system with that of a typical programmable logic controller (PLC). Provide ModBus TRU Gateway or approved equivalent which shall be compatible with Honeywell EBII 7.5 or approved equal.
 - 3. Provide Human Machine Interface (HMI) Panel, C-MORE made or approved equal.
 - 4. A serial or USB port shall be provided for connection to a laptop PC.
 - 5. The Controller and all associated equipment shall be housed in a NEMA 4X rated hinged cabinet manufactured by Hoffman or approved equal.
 - 6. DDC shall have capability to interface for an existing Automated Energy Management System (AEMS) as follows: (If, applicable)
 - a) Provide RS-485 wiring in conduits to the existing Automated Energy Management System Remote Terminal Units (AEMS RTU) which are located in AC Switchboard Rooms.
 - b) The Communication protocol shall be Modbus RTU.
 - c) Data, list in art #1.05.G, shall be available to be transmitted through the digital interface.
 - 7. All hardware and software necessary to fully program the controllers shall be provided by the Contractor. The sequence of operations shall be provided as indicated on the drawings and specified.
- B. Air Handling Unit located in Chiller Plant Room:

1. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.
2. Units monitor or control each input/output point; process information; and download from or upload to operator station.
3. Stand-alone mode control functions operate regardless of network status. Meeting the Sequence of Operation for the Air Handling Unit. ModBus interface with the PRODUCTIVITY 3000 SYSTEM
4. Provide Local Key Pad and Display.
5. Provide 120V power source, control transformer, disconnect switch and surge protection for each panel mounted controller.
6. Provide all hardware and software to program the controllers and the Sequence of Operation as indicated on the drawings. All DDC components shall be installed in a gasketed dust tight enclosure.

2.03 CHILLER PLANT MONITORING/ CONTROL PANELS

A. Direct Digital Control Panel (DDCP) for Chiller Plant Monitoring and Water Treatment System:

1. HMI and display for operator interface to all points in the system. HMI and display and Water Treatment Controllers shall be mounted on the controller cover. See spec Section 15186 for Water Treatment Controller.
2. Direct Digital Control Panels shall be UL listed. All panels shall, as a minimum, have the following features:
 - a) One (1) RS 485 port operating at a minimum of 19.2 KB for LAN communication.
 - b) One (1) RS 232 port for local terminals, modem, chiller interface card or printer.
 - c) Application program shall be stored in battery backed RAM, with the option to back up the application program in on board EPROM, or in non-volatile Flash memory.
 - d) Meet FCC part 15, Subpart J, Class A requirements for electrical emission.
 - e) Battery backed real time clock and RAM. Data to be retained for minimum of one (1) years by battery backup. Time clocks are synchronized between DDCP's.
 - f) Watchdog relay with both normally open and normally closed contacts that switches state on either a power or a hardware or fatal software error. On DDCPs lacking a dedicated Watchdog relay, a dedicated output programmed to act as a Watchdog will suffice.
 - g) Watchdog timer circuit to automatically initiate "Reboot" on detection of processor malfunction.
 - h) Automatic reboot feature to restart the processor after power failing.
 - i) Universal inputs to accept inputs of 0-10 VDC, 4-20 mA, resistance, thermistor, or binary input, selectable with a factory installed jumper.
 - j) Universal outputs, individually fused, suitable for either 0-10 VDC analog or digital outputs.
 - k) Each DDCP shall contain predefined controller software enabling the user to configure:
 - User Reports
 - Sequencing
 - Histories

B. Terminal Unit Controllers:

1. Terminal unit controllers shall be UL listed and have, as a minimum, the following:
 - a) Pre-packaged differential pressure sensor and damper actuator
 - b) Flash memory - eliminating the need for back-up battery
 - c) Permanent storage of changeable parameters
 - d) One (1) RS 485 port operating at 19.2 or 50 kB for LAN communication, computer or modem

- e) One (1) universal RS 232 port for connecting of a local terminal computer or modem
 - f) Universal inputs to accept inputs of 0-5 VDC, 0-10 VDC, 4-20mA, resistance, thermistor or binary, selectable with a jumper
 - g) Digital outputs
 - h) Watchdog timer and circuitry to monitor both hardware and software. If either a fatal hardware or software error is detected, the watchdog circuitry will initiate a system reboot.
 - i) Each having its own addressable node making it part of the ISN
 - j) The ability to upgrade or modify software via the network, eliminating the need to physically access the unit
- C. Unitized cabinet with suitable brackets for wall or floor mounting, located adjacent to each system under automatic control. Provide common keying for all panels.
- 1. Fabricate panels of 0.06-inch thick, furniture-quality steel, or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish.
 - 2. Panel-Mounted Equipment: Controllers, relays, and automatic switches.

2.04 SENSORS

- A. Temperature Sensors- sensors to be Resistance Temperature Device (RTD) type and contain an integral 4-20mA signal conditioner, manufactured by Honeywell C7041 or approved equal. :
- 1. Well sensors shall be thermistor type enclosed in a 304 stainless steel tube with thread brass fitting. Sensor shall fit a ½" threaded saddle or Thredolet®. Sensor shall be furnished with a brass well suitable for 250 psig. If operating pressure is above 250 psig, a stainless steel well shall be supplied. Sensors shall be a Honeywell C7041D or approved equal. The sensor shall have weather- proof utility box
 - 2. Space sensors shall be thermistor type mountable on a standard handy box. All hardware required for mounting on a handy box shall be included. Sensor shall be accurate to $\pm 0.36^{\circ}\text{F}$ between 32°F and 100°F . Sensors shall be a Honeywell C7041C or approved equal. Sensor range shall be 0°F to 100°F and be furnished with all hardware for hand box mounting.
 - 3. For ducts greater than 10 square feet or where stratification is likely, sensor shall be averaging thermistor, RTD or 1000 Ohm resistance elements. Sensor shall be a Honeywell C7041R or equivalent.
- B. Humidity Sensors:
- 1. Humidity sensors shall have $\pm 3\%$ accuracy using ceramic technology. It shall be possible to change sensing elements without recalibrating the sensor. Indoor units shall have an operating range of 0-95% RH non-condensing over a 40°F to 110°F range, Honeywell H7635A2012 or equivalent. Outdoor Honeywell H7635C2015 or equivalent and duct Honeywell H7365B2018 or equivalent humidity sensors shall have a range of 0-95% RH non-condensing and be temperature compensated to operate from -40°F to 240°F .
- C. Pressure Transducer/Sensors - Water:
- 1. Sensor and signal conditioner shall be mounted in NEMA 4X enclosure. Output of sensor shall be 4-20 mA. All sensor wetted parts shall be 316 stainless steel. Accuracy shall be $\pm 0.1\%$ of span, stability $\pm 0.1\%$ of URL.
- D. Differential Air Pressure Sensors:
- 1. Sensor shall be a two-wire 4-20 mA device with a static error of $\pm 0.5\%$ of full scale.
 - 2. Sensor shall be Honeywell P7640U or approved equal. Accuracy shall be $\pm 1\%$ of full scale.
- E. Differential Pressure Switches - Water:
- 1. Differential pressure switches shall be Honeywell PWT100 or approved equal. Switch shall be

mounted in a NEMA 4 enclosure. Temperature compensated range 32°F to 122°F. All sensor wetted parts shall be 316 stainless steel.

F. Temperature Limit Controllers:

1. Temperature limit controller shall be two-position controllers meeting the following requirements:
 - a) Low limit thermostats shall be of the manual reset type with two electrical switches. One set of contacts shall provide a binary input to the ISN controller, the other set of contacts shall be wired to break the safety circuit of the fan starter and prevent fan operation when the starter is in either the "Hand" or "Auto" position. Elements shall be vapor pressure type, responding to the lowest temperature sensed by any 12 inch section. Minimum element length shall be 20 ft. or 1 ft. per square foot of coil face, whichever is greater. Multiple controllers shall be used on large coils where a single element cannot meet the coverage requirements.
 - b) High limit cut-out controllers not furnished as an integral part of an air handling unit shall be two-position manual reset devices wired to shut down the supply fan (and return fan when not used for fire/smoke evacuation) and signal the ISN controller of a critical alarm. Supply air limit controls shall be set at 180°F for supply air and 125°F for return air.

G. Duct Smoke Detectors:

1. Duct smoke detectors shall be UL listed under UL268A. Detectors shall have dual contacts and signal the ISN controller of a critical alarm. Detectors shall be ionization type and operate at air velocities from 300 to 4000 FPM. Visual indication of alarm and pilot must be provided on the front cover of the detector. Contacts shall be provided for remote trouble indication. Sampling tube shall be provided to span the width of duct. Duct smoke detectors shall be compatible with existing upgraded microprocessor controlled fire and intrusion alarm (FIA) system using ADT addressable type detectors manufactured by Edwards System Technology (EST3).

H. Level Transmitter:

1. Level transmitter shall be non contact ultrasound level transmitter where sump volume is greater than 45 gallons. Smaller sumps shall be non-mercury float type switch or conductivity probes.

I. Interface Panels:

1. Interface panels shall be NEMA 12 with subpanels as manufactured by Hoffman or approved equal. Panels shall be assembled and wired by skilled electricians. All wires shall be labeled using heat shrink machine printed sleeves and terminated on terminal strips.

J. Electronic/Pneumatic Transducers (for connection to existing pneumatic systems):

1. Output pressure levels shall be at accuracies of $\pm 0.5\%$ to $\pm 1\%$. Built in volume booster shall provide 10 SCFM output. Provide transducer with a 2" pressure gauge on both inlet and output pressure. Provide means of manual override for positioning outputs.

K. Equipment Operation Sensors as Follows:

1. Status Inputs for Fans: Differential-pressure switch with adjustable range of 0 to 5 inches wg.
2. Electric Motors Operating Condition: Current-Transducer True RMS.

L. Digital-to-Pneumatic Transducers:

1. Convert plus or minus 12-V dc pulse-width-modulation outputs, or continuous proportional current or voltage to 0 to 15 psig.

2.05 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action as indicated.

1. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
2. Spring-Return Motors for Valves: Size for running and breakaway torque of 150 in. x lbf.
3. Spring-Return Motors for Dampers: Size for running and breakaway torque of 150 in. x lbf.

4. Run time: 60 seconds

B. Damper Actuators:

1. Damper actuators shall be electronic type direct coupled (over the shaft), enabling it to be mounted directly to the damper shaft without the need of a connecting linkage. Where noted in the sequence of operation, actuators shall be furnished with end switches. Where used for outside air, damper actuators shall be spring return for failsafe operation. Actuators shall be UL 873 listed and manufactured under ISO 9001.

2.06 CONTROL VALVES

- A. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated. Unit Control valves shall be electronic type Butterfly valves, 3-way as required. Both valve and actuator shall be manufactured under ISO 9001. Valve bodies shall be rated for 600 PSI and shall incorporate a blow-out proof stem design. All valves shall have a minimum range ability of 250 to 1.
- B. Globe and Check Valves NPS 2 and Smaller: Bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
- C. Globe and Check Valves NPS 2-1/2 and Larger: Iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
- D. Hydronic system globe valves shall have the following characteristics:
 1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
 2. Internal Construction: Replaceable plugs and seats of stainless steel or brass.
 - a) Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
 - b) Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.
 3. Sizing: 3-psig maximum pressure drop at design flow rate.

2.07 AIR SUPPLY

- A. Control and Instrumentation Tubing: Type K, seamless copper tubing complying with ASTM B 88 or Type ACR, copper tubing complying with ASTM B 280.
 1. Fittings: Cast-bronze solder fittings complying with ASME B16.18; or wrought- copper solder fittings complying with ASME B16.22, except forged-brass compression-type fittings at connections to equipment.
 2. Joining Method: Soldered or brazed.

2.08 CONTROL WIRING

- A. Electronic Cable for Control Wiring shall be as required by the manufacturer of the equipment being installed.
- B. Provide a source 120 volts or less, 60 Hz., two pole, three wire with ground. All devices shall be UL listed or FM approved.
- C. Transformers shall conform to UL 506. Provide a fuse on the secondary side of the transformer.
- D. Surge Protection: Surge and transient protection shall consist of devices installed external to digital controllers.
- E. Power Line Surge suppressors shall be installed on all incoming A/C power. Provide surge suppressors external to the digital controllers. Surge suppressors shall be rated by UL 1449, and shall have a clamping voltage rating below the following levels:
 1. Normal mode (line to neutral): 350 volts.
 2. Common mode (line to ground): 350 volts.

- F. Sensor and Control Wiring Surge Protection:** Controllers shall have sensor and control wiring surge protection with optical isolation, metal oxide varistor, or silicone avalanche devices. Fuses are not permitted for surge protection.
- G. Wiring:** Provide complete electric wiring for temperature control apparatus, including wiring to transformer primaries. Control circuit conductors that run in the same conduit as power conductors shall have the same insulation level as the power conductors. Circuits operating at 100 volts or more shall be in accordance with the provisions of Division 16. Circuits operating at less than 100 volts shall be defined as low voltage. All cable installed outside of the Control Panels shall be installed in rigid steel conduit. Provide circuit and wiring protection as required by NFPA 70. Conduit and boxes shall be in accordance with division 16 provisions.
- H. AC Control Wiring:**
1. Wiring for 24 volts circuits shall be insulated copper, minimum 18 AWG, and shall be rated for 300 volts AC service. Insulation shall be non-PVC material. Jacket shall be low smoke and shall be free of PVC and PVC-based compounds.
 2. Wiring for 120 volts AC service shall be minimum 14 AWG and shall be rated for 600 volts AC service. See Section 16120, Wire and Cable, for cable insulation and low smoke jacket requirements.
- I. Analog Signal Wiring Between Sensors and ACU Direct Digital Control Equipment:** Signal wiring for analog inputs and analog outputs shall be 18 AWG single or multiple twisted pair. Each pair greater than one shall be 100% shielded and have a 20 AWG drain wire. The exception is direct connected RTD wiring which shall be 18 AWG minimum twisted pair, 100% shielded and with a 20 AWG drain wire. Each wire shall have non-PVC insulation rated at 300 volts AC. Cables shall have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned copper drain wire, and overall cable jacket. Jacket shall be low smoke and shall be free of PVC and PVC-based compounds. Install analog signal wiring in conduit separate from AC power circuits.
- J. Low Capacitance RS-485 Cable Between ACU Direct Digital Control Equipment and Existing Automated Energy Management System Remote Terminal Unit in AC Switchboard Room:**
1. Description:
 - a) pairs, 24AWG stranded (7x32) tinned copper conductors, twisted pairs FEP insulation, overall 100% shield, 22 AWG stranded tinned copper drain wire, overall tinned copper braid shield (90% coverage), FEP jacket.
 2. Conductor:
 - a) Number of Pairs: 2
 - b) Total Number of Conductors: 4
 - c) AWG: 24
 - d) Stranding: 7x32
 - e) Conductor Material: TC - Tinned Copper
 3. Insulation:
 - a) Insulation Material:FEP - Fluorinated Ethylene Propylene
 4. Pair:
 - a) Pair Lay Length: 2 in.
 - b) Pair Twists/ft.: 6
 - c) Pair Color Code:Pair#1: Blue/White with Blue Stripe
 - d) Pair#2: Orange/White with Orange Stripe
 5. Outer Shield:
 - a) Outer Shield Type: Tape/Braid
 - b) Outer Shield Material: Aluminum Foil-Polyester Tape 100% Coverage Braid

TC - Tinned Copper Braid 90% Coverage

6. Outer Shield Drain Wire:
 - a) Outer Shield Drain Wire AWG: 22
 - b) Outer Shield Drain Wire Stranding: 7x32
 - c) Outer Shield Drain Wire Conductor: TC - Tinned Copper
7. Outer Jacket:
 - a) Outer Jacket Material: FEP - Fluorinated Ethylene Propylene
 - b) Outer Jacket Color: Gray
8. Mechanical Characteristics:
 - a) Operating Temperature Range: -40degC To +150degC
 - b) Min. Pulling Tension: 50 lbs.
 - c) Min. Bend Radius (Install): 2.75 in.
9. Applicable Specifications and Agency Compliance: **a)**
NEC/(UL) Specification **CMP b)**
CEC/C(UL) Specification **CMP**
10. Flame Test:
 - a) UL Flame Test: UL910 Steiner Tunnel
 - b) C(UL) Flame Test: FT6
11. Electrical Characteristics
 - a) Nominal Characteristic Impedance: 120 Ohms
 - b) Nominal Capacitance Conductor to Conductor @ 1 KHZ: 12pF/ft **c)**
Nominal Cap. Cond. To Other Cond. & Shield @ 1 KHZ: 22pF/ft **d)**
Nominal Velocity of Propagation: 76%
 - e) Nominal Conductor DC Resistance @ 20 Deg. C: 24 Ohms/1000ft **f)**
Nominal Outer Shield DC Resistance @ 20 Deg. C: 2.4 Ohms/1000ft **g)**
Operating Voltage: U 300 V RMS
12. Put-ups:
 - a) Put-ups: 2000 ft.
13. Submittal:
 - a) Submit cable specifications and test certifications.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that power supply is available to control panels.
- B. Verify that duct-, pipe-, and equipment-mounted devices and wiring are installed before proceeding with installation.

3.02 INSTALLATION

- A. Install equipment level and plumb.
- B. Install software in Direct Digital Control Panels (DDCP). Implement all features of programs to specified requirements and as appropriate to sequence of operation.
- C. Connect and configure equipment and software to achieve sequence of operation specified.
- D. Verify location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. Locate all 60 inches above the floor.
- E. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

- F. Install guards on space temperature sensors. Provide security hardware and fasteners.
- G. Install labels and nameplates to identify control components according to Division 15 Section "Basic Mechanical Materials and Methods."
- H. Install labels and nameplates to identify control components according to Division 15 Section "Mechanical Identification."
- I. Install hydronic instrument wells, valves, and other accessories according to Division 15 Section "Piping Systems."

3.03 PNEUMATIC PIPING INSTALLATION

- A. Install piping in pipe chases with easy access.
 - 1. Install copper tubing with maximum unsupported length of 36 inches, for tubing exposed to view.
- B. In concealed locations, such as pipe chases and suspended ceilings with easy access, install copper.
- C. In concrete slabs, furred walls, or ceilings with no access, install copper or polyethylene tubing in rigid steel electrical conduit.
 - 1. Install polyethylene tubing in electrical conduit extending 6 inches above floor line; pull tubing into electrical metallic tubing after pour.
- D. Purge tubing with dry, oil-free compressed air before connecting control instruments.
 - 1. Bridge cabinets and doors with flexible connections fastened along hinge side; protect against abrasion. Tie and support tubing.
- E. Number-code or color-code control air piping for future identification and service of control system, except local individual room control tubing.

3.04 ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. General Requirements:
 - 1. All wiring between DDCP's, sensors, control devices and necessary conduit for the wiring shall be provided under this section of the specification. All control wiring which is provided under this section of the specification shall be in accordance with requirements set forth in Division 16 - Electrical and the National Electrical Codes.
 - 2. Provide control wire and cable including communication media required for successful operation of the BAS. All wiring and cable shall comply with national and local electrical codes.
- B. Wire and Cable:
 - 1. Low capacitance RS-485 Communication cable shall be twisted, shielded, and a minimum of 24 AWG. Shielding shall be grounded to the signal ground. The cable shall conform to Belden 9272 or equal. RS-485 cable and conduit shall be installed between the DDCP and the existing AEMS RTU cabinet in the AC Switchboard Room with minimum of 10 feet of coiled cable left in the AEMS RTU cabinet for termination to internal components by WMATA personnel.
 - 2. Sensor Wiring: Sensor wiring shall be 18 AWG as specified, shielded (if necessary), 2 or 3 wire to match analog function hardware.
 - 3. Control wiring for digital functions shall be 22 AWG minimum, the insulation must be rated at 300 volt minimum.
 - 4. Control wiring for analog functions shall be 22 AWG minimum, the insulation must be rated at 300 volt minimum, shielded (if required), 2 or 3 wire to match analog function hardware.
- C. Conduit: All wiring within the mechanical space shall be installed in galvanized rigid steel conduit with threaded fittings. Wiring to sensors mounted on air conditioning units and associated chilled water piping shall be installed in a minimum 18-inch long length of liquid tight flexible metal conduit at the sensor location. Existing conduits for control wiring shall be retained and reused where the routing for existing conduits is suitable for new conduit routing requirements for new control wiring work subject to

- approval by the Authority Representative (AR).
- D. Labeling: All wiring, including input/output identifications, components and enclosures shall be clearly labeled and documented. All labeling shall be in a logical consecutive order. All labeling shall appear on the as-built drawings clearly and precisely duplicating the actual installation.
 - E. All work shall be installed in accordance with both national and governing codes. Where the drawings and job specifications conflict with code requirements, the contractor shall make the necessary adjustments and shall base his bid on an installation which complies with those codes. Where plans and specifications exceed code requirements, the plans and specifications shall govern.
 - F. Install raceways, boxes, and cabinets according to Division 16 Section "Raceways and Boxes."
 - G. Install building wire and cable according to Division 16 Section "Wire and Cable."
 - H. Install signal and communication cable according to Division 16 Section "Wire and Cable" with the following additional requirements:
 - 1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
 - 2. Install exposed cable in galvanized rigid steel conduit.
 - 3. Install concealed cable in galvanized rigid steel conduit.
 - 4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
 - 5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
 - 6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
 - I. Make connection using RS-485 cable between the DDCP and the existing AEMS RTU located in the - nearest AC Switchboard Room. For a DDCP located in a mechanical equipment room on the mezzanine level at or near the center of the passenger station, connect the DDCP to the existing AEMS RTU located in the AC Switchboard Room that is nearest, or if distance to each AC Switchboard Room is approximately equal, connect to the existing AEMS RTU in the AC Switchboard Room located on the end of the station that includes the Communications Room_Chiller Plant Room as indicated on the drawings.
 - J. Connect manual-reset limit controls independent of manual-control switch positions.
 - K. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.
 - L. Connect electrical components to wiring systems and to ground as indicated and as instructed by the manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque values for equipment connectors. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals according to tightening requirements specified in UL 486A.
 - M. Grounding: Ground controllers and cabinets to a good earth ground. Ground controller to a ground in accordance with Division 16 provisions. Grounding of the green ac ground wire at the breaker panel is not adequate. Run metal conduit from controller panels to adequate building ground. Ground sensor drain wire shields at controller end.
 - N. The Contractor shall be responsible for correcting all associated ground loop problems.
 - O. Perform installation under supervision of competent technicians regularly employed in the installation of DDC systems. Provide components for a complete and operational DDC system. Provide all power and signal wiring to controlled devices such as valve and damper actuators. Source of power wiring shall be extended from the DDC panels. A control power source for each DDC panel is indicated on the electrical drawings. The DDC panel is identified as Temperature Control Panel (TCP) on the electrical

drawings.

3.05 CONNECTIONS

- A.** Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
 - 1. Install piping adjacent to machine to allow service and maintenance.
- B.** Ground equipment.
 - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.06 FIELD QUALITY CONTROL

- A.** Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections.
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest.
 - 4. Pressure test control air piping at 30 psig or 1.5 times the operating pressure for 24 hours, with maximum 5-psig loss.
 - 5. Pressure test high-pressure control air piping at 150 psig and low-pressure control air piping at 30 psig for 2 hours, with maximum 1-psig loss.
 - 6. Calibration test electronic controllers by disconnecting input sensors and simulating operation with compatible signal generator.
- B.** Engage a factory-authorized service representative to perform startup service.
- C.** Replace damaged or malfunctioning controls and equipment.
 - 1. Start, test, and adjust control systems.
 - 2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.
 - 3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.
- D.** Verify DDC as follows:
 - 1. Verify software including automatic restart, control sequences, scheduling, reset controls, and occupied/unoccupied cycles.
 - 2. Verify operation of operator interface via a laptop computer.
 - 3. Verify local control units including self-diagnostics.
 - 4. Verify operation of annunciator panels.
 - 5. Verify successful transmission of specified data points through the digital interface between the DDC and the existing Automated Energy Management System, Remote Terminal Unit (AEMS RTU).

3.07 DEMONSTRATION

- A.** Engage a factory-authorized service representative to train WMATA maintenance personnel to adjust, operate, and maintain control systems and components.
 - 1. Train WMATA maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
 - 2. Provide operator training on data display, alarm and status descriptors, requesting data, executing

commands, calibrating and adjusting devices, resetting default values, and requesting logs. Include a minimum of 40 hours' dedicated instructor time on-site.

3. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
4. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
5. Schedule training with AR with at least seven days' advance notice.

3.08 ON-SITE ASSISTANCE AND TRAINING

- A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project site visits, when requested by AR, to adjust and calibrate components and to assist WMATA personnel in making program changes and in adjusting controls to suit actual conditions.
- B. A minimum of two (2) days of operator training shall be provided for four (4) system operators.
- C. Submit lesson plans to the AR for the training phases to include type of training to be provided and a list of reference material for review and approval by the AR.
- D. Provide the services of competent instructors who will give full instruction to designated personnel in the operation, maintenance, and programming of the BAS. Coordinate the training specifically to the system installed. Instructors shall be thoroughly familiar with the installed system. The number of training days of instruction furnished shall be as specified. Provide a training manual for each student at each training phase which describes in detail the data included in each training program. Provide four (4) additional copies to the Owner. Training shall include but not be limited to:
 1. Operation of equipment
 2. Programming
 3. Diagnostics
 4. Failure recovery procedures
 5. Alarm response

* * *

END OF SECTION

SECTION 15950

SYSTEM BALANCING AND TESTING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. This section specifies water balancing, adjusting and performance-testing of chillers and cooling towers

1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
1. NEBB: Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems.
 2. ASHRAE III: Practices for Measurement, Testing, Adjusting and Balancing of Building HVACR Systems.
- B. Instrument Calibration:
1. Calibrate instruments required for air and water balance within six months prior to use on this project.

1.03 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Shop Drawings:
1. Test and instrument location plans.
 2. After initial balancing measurements, submit shop drawings for additional equipment such as pressure taps and balancing cocks necessary to effect proper water balance.
- B. Certification:
1. Complete water-balance report certified by professional engineer licensed in the jurisdiction where the work is to be performed. Water balancing and testing includes only the chillers and cooling towers in this project.
 2. Collect data in accordance with referenced standards.
 3. Submit complete data on standard NEBB testing and balancing report forms without omissions or on approved report forms bearing identical data. Data to include types, serial numbers and calibration dates of instruments.
 4. Water-balance test reports to include data covering the following:
 - a. Chillers: Section 15625A.Pumps: Section 15185.

PART 2 - PRODUCTS

- 2.01** Provide, as specified in Section 15205, additional equipment, such as pressure taps and balancing cocks necessary to effect proper water balance.

PART 3 - EXECUTION

3.01 BALANCING AND PERFORMANCE TESTING:

- A. After completion of installation of chillers, cooling towers, and pumps, and prior to acceptance by the

Engineer, adjust and balance water systems and appurtenances applicable to those systems to deliver the water quantities as specified and as shown. Make final tests after modifications are completed. Seal instrument test holes upon completion of balancing operation.

B. Water Balance:

1. Perform testing in accordance with referenced NEBB Standard, ASHRAE 111 or other approved standard.
2. Perform tests, adjust and balance when outside conditions approximate design conditions as shown for heating and cooling functions.
3. Balancing cock: Provide reference mark to permit reset after shutoff.

* * *

END OF SECTION

SECTION 16050

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY:

- A. This Section includes the following:
 - 1. Supporting devices for electrical components.
 - 2. Electrical identification.
 - 3. Electrical demolition.
 - 4. Cutting and patching for electrical construction.
 - 5. Touchup painting.

1.3 QUALITY ASSURANCE:

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

1.4 COORDINATION:

- A. Coordinate chases, slots, inserts, sleeves, and openings with mechanical construction work and arrange in building structure to facilitate the electrical installations that follow.
- B. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work.
- C. Where electrical identification devices are applied to field-finished surfaces, coordinate installation of identification devices with completion of finished surface.
- D. Where electrical identification markings and devices will be concealed by acoustical ceilings and similar finishes, coordinate installation of these items to prevent damage to existing ceiling tile. The contractor shall repair damaged ceiling or wall in the work affected area at no cost to WMATA.

PART 2 - PRODUCTS

2.1 SUPPORTING DEVICES:

- A. Material: Cold-formed steel, with corrosion-resistant coating acceptable to authorities having jurisdiction.
- B. Metal Items for Use Outdoors or in Damp Locations: Hot-dip galvanized steel.
- C. Slotted-Steel Channel Supports: Flange edges turned toward web, and 9/16-inch- diameter slotted holes at a maximum of 2 inches o.c., in webs.
 - 1. Comply with applicable AISC and ASTM standards for slotted channel framing.
 - a) Channel Thickness: Selected to suit structural loading.
 - b) Fittings and Accessories: Products of the same manufacturer as channel supports.
- D. Nonmetallic Channel and Angle Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch diameter holes at a maximum of 8 inches o.c., in at least one surface.
- E. Fittings and Accessories: Products of the same manufacturer as channels and angles.
- F. Fittings and Accessory Materials: Same as channels and angles, except metal items may Be stainless steel.
- G. Pipe Sleeves: ASTM A 53, Type E, Grade A, Schedule 40, galvanized steel, plain ends.
- H. Expansion Anchors: Carbon-steel wedge or sleeve type.
- I. Toggle Bolts: All-steel springhead type.
- J. Powder-Driven Threaded Studs: Heat-treated steel.
- K. For conduit and cable support, see section 16130.

2.2 ELECTRICAL IDENTIFICATION:

- A. Identification Devices: A single type of identification product for each application category. Use colors prescribed by ANSI A13.1, NFPA 70, and these Specifications.

- B. Colored Adhesive Marking Tape: Self-adhesive vinyl tape, not less than 1 inch wide by 3 mils thick.
- C. Tape Markers for Wire: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.
- D. Engraved-Plastic Labels, Signs, and Instruction Plates: Engraving stock, phenolic plate, fiberboard tag, plastic labels punched or drilled for mechanical fasteners 1/16-inch minimum thickness for signs up to 20 sq. in. and 1/8-inch minimum thickness for larger sizes. Engraved legend in white letters on black background.
- E. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32 stainless-steel machine screws with nuts and flat lock washers.

2.3 TOUCH-UP PAINT:

- A. For Equipment: Equipment manufacturer's paint selected to match installed equipment finish.
- B. Galvanized Surfaces: Zinc-rich paint recommended by item manufacturer.

PART 3 - EXECUTION

3.1 ELECTRICAL EQUIPMENT INSTALLATION:

- A. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide the maximum possible headroom and keep at 2'-0" above floor.
- B. Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.
- C. Equipment: Install to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations.
- D. Right of Way: Give to raceways and piping systems installed at a required slope.

3.2 ELECTRICAL SUPPORTING DEVICE APPLICATION:

- A. Damp Locations and Outdoors: Hot-dip galvanized materials or nonmetallic, U-channel system components.
- B. Dry Locations: Steel materials.
- C. Selection of Supports: Comply with manufacturer's written instructions.

- D. Strength of Supports: Adequate to carry present and future loads, times a safety factor of at least four; minimum of 200-lb (90-kg) design load.

3.3 SUPPORT INSTALLATION:

- A. Install support devices to securely and permanently fasten and support electrical components.
- B. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assemblies and for securing hanger rods and conduits.
- C. Install 1/4-inch diameter or larger threaded steel hanger rods, unless otherwise indicated.
- D. Install metal channel racks for mounting, disconnect switches, control enclosures, pull and junction boxes, and other devices unless components are mounted directly to structural elements of adequate strength.
- E. Install sleeves for cable and raceway penetrations of concrete walls. Install sleeves for cable and raceway penetrations of masonry and fire-rated gypsum walls and of all other fire-rated wall.
- F. Securely fasten electrical items and their supports to the building structure, unless otherwise indicated. Perform fastening according to the following unless other fastening methods are indicated:
 - 1. Wood: Fasten with wood screws or screw-type nails.
 - 2. Masonry: Toggle bolts on hollow masonry units and expansion bolts on solid masonry units.
 - 3. Existing Concrete: Expansion bolts.
 - 4. Instead of expansion bolts, threaded studs driven by a powder charge and provided with lock washers may be used in existing concrete.
 - 5. Steel: Welded threaded studs or spring-tension clamps on steel.
 - a. Field Welding: Comply with AWS D1.1.
 - 6. Welding to steel structure may be used only for threaded studs, not for conduits, pipe straps, or other items.
 - 7. Light Steel: Sheet-metal screws.
 - 8. Fasteners: Select so the load applied to each fastener does not exceed 25 percent of its proof-test load.

3.4 IDENTIFICATION MATERIALS AND DEVICES:

- A. Install at locations for most convenient viewing without interference with operation and maintenance of equipment.
- B. Coordinate names, abbreviations, colors, and other designations used for Electrical identification with corresponding designations indicated in the Contract Documents or required by codes and standards. Use consistent designations throughout Project.
- C. Self-Adhesive Identification Products: Clean surfaces before applying.
- D. Tag and label circuits designated to be extended in the future. Identify source and circuit numbers in each cabinet, pull and junction box, and outlet box.
- E. Install warning, caution, and instruction signs where required to comply with 29 CFR, Chapter XVII, Part 1910.145, and where needed to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation.

3.5 FIRESTOPPING:

- A. Apply firestopping to cable and raceway penetrations of wall to achieve 2 hours fire- resistance rating.

3.6 DEMOLITION:

- A. Protect existing to remain electrical equipment and installations indicated. If damaged or disturbed in the course of the Work, remove damaged portions and install new products of equal capacity, quality, and functionality at no extra cost to WMATA.
- B. Accessible Work: Remove exposed electrical equipment and installations, indicated to be demolished, in their entirety.
- C. Abandoned Work: Cut and remove buried raceway and wiring, indicated to be abandoned in place. Cap raceways and patch surface to match existing finish.
- D. Remove demolished material from Project site.
- E. Remove, store, clean, reinstall, reconnect, and make operational components indicated for relocation.

3.7 CUTTING AND PATCHING:

- A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required

to permit electrical installations. Perform cutting by skilled mechanics of trades involved.

- B. Repair and refinish disturbed finish materials and other surfaces to match existing adjacent undisturbed surfaces. Install new fireproofing where existing firestopping has been disturbed. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

3.8 FIELD QUALITY CONTROL:

- A. Inspect installed components for damage and faulty work, including the following:
 - 1. Supporting devices for electrical components.
 - 2. Electrical identification.
 - 3. Electrical demolition.
 - 4. Cutting and patching for electrical construction.
 - 5. Touchup painting.

3.9 REFINISHING AND TOUCHUP PAINTING:

- A. Refinish and touch up paint. Paint materials and application requirements are specified in Section 09920.
- B. Clean damaged and disturbed areas and apply primer, intermediate, and finish coats to suit the degree of damage at each location.
- C. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.
- D. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
- E. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.10 CLEANING AND PROTECTION:

- A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.
- B. Protect equipment and installations and maintain conditions to ensure that coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

* * *

END OF SECTION

SECTION 16060

GROUNDING AND BONDING

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. This section specifies providing complete grounding and bonding system.
- B. Related Work Specified Elsewhere:

- 1. Wire, cable and busways: Section 16120.

1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
 - 1. Comply with codes and regulations of the jurisdictional authorities.
 - 2. National Electrical Code (NEC)
 - 3. ANSI/IEEE 80-2000, IEEE Guide for Safety in AC Substation Grounding.
 - 4. UL 467, Grounding and Bonding Equipment..
 - 5. American Standards of Testing and Materials (ASTM) B187-00, Standard Specification for Copper Bar, Bus Bar, Rod and Shapes.
 - 6. ITS: Directory of ITS Listed Products.
- B. Source Quality Control:
 - 1. Each item, except for exothermic-welded electrical connections, listed per referenced UL or ITS directory.

1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
 - 1. Shop Drawings.
 - 2. Certification.
 - a. Certified test reports verifying that ground resistance of each ground grid when installed and each ground bus when connected to ground grid does not exceed specified values.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Mark each item in accordance with applicable reference standard.
- B. Ship each unit securely packaged and labeled for safe handling and to avoid damage.
- C. Store equipment in secure and dry storage facility.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

- A. Grounding and Bonding Equipment:
 - 1. General Requirements:
 - a. UL 467.
 - 2. Grounding conductor:
 - a. Equipment grounding conductor:
 - 1) Sized in accordance with NEC Article 250-122 unless otherwise shown.
 - 2) Insulated equipment grounding conductor: Single-conductor cable as specified in Section

- 16120.
- 3) Bare equipment grounding conductor integral with multiple-conductor cable: Section 16120.
- b. Bonding conductor for electrical continuity:
 - 1) Insulated or bare conductors, as shown, in accordance with the following:
 - a) Insulated conductors: As specified in Section 16120 for single-conductor cable.
 - b) Bare conductor: Section 16120.
 - 2) Size: As shown or as specified.
- 3. Terminal lugs:
 - a. For 4/0 AWG and smaller conductors: Copper compression terminal lugs.
 - b. For 250 MCM and larger: Long-barrel, copper, double-compression terminal lugs.
- 4. Ground connector:
 - a. O-Z, Type KG or equal.
 - b. Two-piece, designed for connecting grounding conductor to bus bar.
 - c. Copper-alloy body and silicon-bronze bolt, nut and lock washer with interlocking clamp.
- 5. Jumpers: Copper braided or leaf-type flexible jumper, size as necessary.

PART 3 - EXECUTION

3.01 GROUNDING:

A. Ground Connections:

- 1. Use terminal lug to connect grounding conductor to equipment enclosure. Use ground connector to connect grounding conductor to ground bus. Secure connector or terminal lug to the conductor so as to engage all strands equally. Install terminal lug using tools and pressure recommended by the manufacturer. Indent mark terminal lug with the number of die used for installation.
- 2. Splices in grounding conductor are prohibited.
- 3. For making ground connections located indoors and in confined spaces located outdoors such as manholes, use exothermic welds with low-smoke, low-emission process.

B. Equipment Grounding Conductor: Provide insulated equipment grounding conductor for following services and as shown:

- 1. Feeders.
- 2. Branch circuits.

C. Grounding for Personnel Safety:

- 1. Bond and ground exposed metallic structures in open areas to separate grounding electrode in accordance with the following requirements:
 - a. Ground metal frame of air conditioning unit to existing ground bus or other ground electrode as shown.
 - b. Bond metal ducts at locations of flexible connections to metal frame of air conditioning unit using #6 green insulated grounding conductor

3.02 FIELD QUALITY CONTROL:

- A. Conduct tests in presence of Engineer.
- B. Test metallic conduits and raceways, metallic enclosures for equipment, metallic structures, metallic covers, cover frames and bodies of junction boxes, for continuity to grounding system.

* * *

END OF SECTION

SECTION 16120

WIRE AND CABLE

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. This section specifies providing wire and cable.
- B. Definitions:
 - 1. Type I cable: Cable having low smoke-generating characteristics.
 - 2. Type II cable: Cable without specific low smoke-generating characteristics.
- C. Requirements for single-conductor cable as stated apply to both Type I cable and Type II cable except as otherwise specified.
- D. Related Work Specified Elsewhere:
 - 1. Wiring accessories: Section 16125.

1.2 QUALITY ASSURANCE:

- A. Qualifications: Select a manufacturer who is engaged in production of similar wire and cable.
- B. Codes, Regulations, Reference Standards and Specifications:
 - 1. Comply with codes and regulations of the jurisdictional authorities.
 - 2. NEC.
 - 3. ICEA: S-66-524, S-68-516, S-19-81.
 - 4. IEEE: 1202.
 - 5. NEMA: BU1, WC7, WC8.
 - 6. ANSI: C37.20.1,2&3, Z55.1.
 - 7. UL: 44, 62, 857, 1685, Electrical Construction Materials Directory.
 - 8. ASTM: B3, B8, D471, E662.
 - 9. ETL: Directory of ETL Listed Products

C. Source Quality Control:

1. Cable: Listed or labeled per UL or ETL directory.

1.3 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Shop Drawings.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Mark each single-conductor cable to show label per referenced UL or ETL directory, size, voltage, manufacturer and number of conductors or phases in accordance with NEC requirements.
- B. Ship each unit securely packaged and labeled for safe handling and shipment.
- C. Store products in a dry and secure facility.

PART 2 - PRODUCTS

2.1 PRODUCTS AND MATERIALS:

- A. General Requirements for Single-Conductor Cable:
 1. Type and size: Type I, size as shown in drawing.
 2. Rated voltage: 600 volts.
 3. Conductors:
 - a. ASTM B3 or B8 annealed copper.
 - b. Size 10AWG and smaller: Solid or Class B or Class C stranded.
 - c. Size 8AWG and larger: Class B stranded.
 4. Standards: Except as modified, wires and cable complying with the following standards:
 - a. Cross-linked polyethylene (XLPE) insulated cable: ICEA S-66-524, NEMA WC7.
 - b. Other cable: ICEA S-68-516, NEMA WC8.

5. Non-metallic jacket for single-conductor cable and individual conductors of multiple-conductor cable:
 - a. Type I cable: Chlorosulfonated polyethylene or cross-linked polyolefin.
 - b. Type II cable: Chlorosulfonated polyethylene, cross-linked polyolefin, or heavy-duty neoprene.
 - c. Jacket materials other than cross-linked polyolefin complying with ICEA S-68-516, NEMA WC8. Jacket material free of PVC and PVC-based compounds.
 6. Flame retardancy: Single-conductor cable demonstrating flame retardancy in accordance with the following:
 - a. Single-conductor cable passing vertical flame test in accordance with UL1581 or ICEA S-19-81. Cable size for testing: 14AWG.
 - b. Single-conductor cable passing vertical tray flame test, using ribbon gas burner in accordance with IEEE 1202.
 7. Smoke generation: For Type I cables, single-conductor cable jacket materials demonstrating low-smoke generation when tested in accordance with ASTM E662 by independent, nationally recognized testing agency.
 8. Applied voltage testing:
 - a. Single-conductor cable to be given applied ac voltage dielectric-strength test, i.e., six-hour water-immersion test.
- B. Single-Conductor Cable:
1. Type I cable: Insulated with ethylene-propylene-rubber with non-metallic jacket as specified. UL44 Type RHW-2.
 2. Type II cable: Insulated with ethylene-propylene-rubber with non-metallic jacket or unjacketed filled cross-linked polyethylene. UL44 Type RHW-2.
 3. Color coding: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.
- C. Bare Conductors: ASTM B3 or B8, annealed copper conductor; 8AWG and larger, Class B stranded, unless otherwise shown or specified.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Install type I cable as specified.
- B. Install single-conductor cable in conduit. Splicing of cable is prohibited.
- C. Minimum bending radius 12 times outer diameter of cable. Where shown, use shorter bending radius as permitted by NEC, Appendix H of ICEA S-66-524, NEMA WC7 and cable manufacturer.
- D. To facilitate pulling cable, use listed per UL or ETL directory lubricant recommended by cable manufacturer.

3.2 IDENTIFICATION:

- A. Identify cable terminations, feeders and power circuits using non-metallic fiberboard tags or plastic labels. Attach tags to cable with slip-free plastic lacing or nylon bundling straps. Use designation of associated equipment served.

3.3 FIELD QUALITY CONTROL:

- A. Furnish equipment required to perform tests. Prior to insulation and high-potential tests, disconnect instruments and equipment which might be damaged during such tests. Conduct tests in presence of the Authority Representative.
- B. Submit test procedure for approval and perform approved tests including, but not limited to, the following:
 - 1. Single-conductor cable:
 - a. Test continuity of cable conductors using ohmmeter.
 - b. Proof-test insulation resistance to ground and between insulated conductors for minimum of one minute using 1,000-volt megger. Insulation resistance: 200,000 ohms minimum.
 - c. When cable shows unsteady insulation resistance of less than 200,000 ohms, perform high-potential test at 80 percent of factory ac test voltage or as recommended by cable manufacturer.
- C. Submit certified test reports.

END OF SECTION

SECTION 16125

WIRE CONNECTION ACCESSORIES

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. This section specifies providing wire-connection accessories, such as connectors, terminal lugs and fittings, bundling straps, insulating tape and resin.

1.2 QUALITY ASSURANCE:

- A. Qualifications: Select a manufacturer who is engaged in production of similar wire connection accessories.

- B. Codes, Regulations, Reference Standards and Specifications:

- 1. Comply with codes and regulations of the jurisdictional authorities.
- 2. NEC.
- 3. UL: 486, Electrical Construction Materials Directory.
- 4. ASTM: D149, D257, D412, D570, D638, D696, D792, D1000, D1518, D5034.
D5035, D2240, G21.
- 5. ANSI: C119.1.
- 6. ITS: Directory of ITS Listed Products.

- C. Source Quality

Control:

- 1. Connectors, terminal lugs and fittings listed, per referenced UL or ITS directory.
- 2. Factory testing: Submit certified copies of test report for cable splice and tap-insulation/sealing kits as specified.

1.3 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and With the additional requirements as specified for each:

- A. Shop Drawings.

- B. Certification.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Mark each item in accordance with applicable reference standard.
- B. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage.
- C. Store products in secure and dry storage facility.

PART 2 - PRODUCTS

2.1 PRODUCTS AND MATERIALS:

- A. Connectors, Terminal Lugs and Fittings:
 - 1. In accordance with UL 486.
 - 2. For 10AWG and smaller conductor cable: Tin-plated copper pressure connectors with nonflammable, self-extinguishing insulation grip with temperature rating equal to that of conductor insulation.
 - 3. For 8AWG to 4/0 AWG conductor cable: Tin-plated copper compression connectors and terminal lugs with nylon insulating sleeve for insulation grip.
- B. Bundling Straps:
 - 1. Self-locking steel barb on one end, with tapered strap of self-extinguishing nylon, temperature rating minus 40F to plus 185F.
- C. Insulating Tape:
 - 1. Plastic tape: Vinyl plastic tape with rubber-based pressure-sensitive adhesive, pliable at zero degree F with the following minimum properties when tested in accordance with ASTM D1000:
 - a. Thickness: 8.5 mils.
 - b. Breaking strength: 20 pounds per inch width.
 - c. Elongation: 200 percent.

- d. Dielectric breakdown: 10,000 volts.
 - e. Insulation resistance, indirect method of electrolytic corrosion: 1,000,000 megohms.
 - 2. Rubber tape: Silicone-rubber tape with silicone pressure-sensitive adhesive, with the following minimum properties when tested in accordance with ASTM D1000:
 - a. Thickness: 12 mils.
 - b. Breaking strength: 13 pounds per inch width.
 - c. Elongation: 525 percent.
 - d. Dielectric breakdown: 13,000 volts.
 - e. Insulation resistance, indirect method of electrolytic corrosion: 1,000,000 megohms.
- D. Epoxy Resin: Suitable for insulating and moisture sealing cable splices, with the following minimum properties:
 - 1. Dielectric strength, ASTM D149: 400 volts per mil.
 - 2. Volume resistance, ASTM D257: 2.8×10^{15} ohm per centimeter cube at 30C.
 - 3. Water absorption, ASTM D570:
 - a. 0.193 percent in 24 hours at 23C.
 - b. 0.62 percent in 24 hours at 53C.
 - 4. Tensile strength, ASTM D638: 8,000 psi.
 - 5. Elongation, ASTM D638: 2.4 percent.
 - 6. Coefficient of expansion, ASTM D696: 6.8×10^{-5} inch per inch per degree C.

PART 3 - EXECUTION

3.1 SPLICES AND TERMINATIONS:

- A. Make wire and cable splices in outlet, junction or pull boxes, in cable troughs or in equipment cabinets. Splices in conduit are prohibited.

- B. Secure connectors or terminal lugs to conductor so as to engage all strands equally.
- C. Do not rupture insulation nor expose bare conductors.
- D. Install compression connectors and terminal lugs using tools and pressure recommended by manufacturer. Indent mark connectors and terminal lugs with number of die used for installation.
- E. Apply anti-corrosion joint compound to connectors, terminal lugs and bolting pads Before installation.

END OF SECTION

SECTION 16130

RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. This section specifies providing conduit, raceways and boxes to form raceway and support system for power and control cables.

1.2 QUALITY ASSURANCE:

- A. Qualifications: Select a manufacturer who is engaged in production of similar conduit, raceways and boxes.
- B. Codes, Regulations, Reference Standards and Specifications:
 - 1. Comply with codes and regulations of the jurisdictional authorities.
 - 2. NEC.
 - 3. NEMA: 250, VE1, TC-2, TC-14.
 - 4. ANSI: C80.1, C80.5, Z55.1.
 - 5. UL: 5, 6, 50, 94, 360, 514A, 514B, 514C, 651, 884.
 - 6. FS: FF-S-325C, FF-S-760, TT-S-227.
 - 7. ASTM: A47, A123, A185, A507, A532, A536, A615, A653, B138, B455, B584, B633, C109, C173, C231, D149, D495, D570, D638, D648, D790, D794.
 - 8. AASHTO: Standard Specifications for Highway Bridges (SSHB).
 - 9. ITS: Directory of ITS listed products.
- C. The following items to be listed or labeled per referenced UL or ITS directory:
 - 1. Conduit and fittings.
 - 2. Boxes.

1.3 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Shop Drawings.
- B. Certification.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Mark each item in accordance with applicable reference standard.
- B. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.
- C. Store products in secure and dry storage facility.

PART 2 - PRODUCTS

2.1 PRODUCTS AND MATERIALS:

- A. General Requirements for Conduit, Raceways, Boxes and Fittings:
 - 1. Size: As shown, minimum conduit size 3/4 inch.
 - 2. Materials:
 - a. Steel sheet: ASTM A507.
 - b. Zinc-coated steel sheet: ASTM A653, coating G235.
 - c. Cast iron: ASTM A532.
 - d. Ductile iron: ASTM A536. e.
Malleable iron: ASTM A47.
 - f. Bronze extrusion: ASTM B455, Alloy C38500.
 - g. Bronze casting: ASTM B584, Alloy C83600.
 - 3. Zinc coating:
 - a. Hot-dip galvanizing: ASTM A123.
 - b. Electro galvanizing: ASTM B633.
- B. Galvanized-Steel Rigid Conduit and Fittings: UL 6 and ANSI C80.1, zinc coating tested in

accordance with reference test in appendix.

C. Liquid-Tight Flexible Conduit and Fittings:

1. Applicable requirements of UL 360.
2. Flexible galvanized-steel core with extruded liquid-tight neoprene or PVC jacket overall.
3. Sizes up to 1-1/4 inch provided with continuous copper bonding conductor, spiral wound between convolutions.

D. Conduit Expansion Fittings:

1. Materials:
 - a. For galvanized-steel rigid conduit:
 - (1) Expansion fittings: Steel or malleable iron, hot-dip galvanized.
2. Conduit expansion fitting: Weatherproof.
3. Metallic fittings equipped with bonding jumper cable to provide electrical continuity.

E. Conduit Connector Fittings:

1. UL 514B, material and finish similar to that of conduit with which they are to be used.
2. For enclosures, boxes and gutters in electrical rooms and aboveground indoor locations: Threaded nylon-insulated bushing and locknuts.
3. For enclosure having punched or formed knockout for conduit entry in outdoor locations, except electrical rooms: Threaded watertight fitting with gasket, nylon-insulated throat and sealing locknut.

F. Conduit and Cable Supports:

1. Retaining straps and fasteners: FS FF-S-760, with the following additional requirements:
 - a. Type, style and size: As necessary.
 - b. Material and finish: Stainless steel.
 - c. For separating conduit from masonry surface: Hot-dip

galvanized malleable-iron spacer assembled with Style A strap.

- d. For vertical run of metallic-sheath cable: Basket-weave cable support.
- e. For fastening conduit or cable to channel inserts: Galvanized-steel fasteners.

G. Boxes:

1. Junction and pull boxes:

- a. Internal volume up to 100 cubic inches, metallic boxes: UL 514A, non-metallic boxes: UL514C; internal volume above 100 cubic inches, UL 50.
- b. Flush-mounted or surface-mounted as shown.
- c. Size: Suitable to accommodate conduit, raceways, ducts, number of cables and splices shown.
- d. Material and finish:

(1) Metallic boxes:

- A. Hot-dip galvanized or electro galvanized after fabrication.

- H. Expansion Bolt Anchors: FS FF-S-325C Group II, galvanized, type and class as approved.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. General:

- a. Use size, type, general routing, location of conduit, raceways, boxes and cabinets as shown and specified.
- b. Install metallic raceway, fittings, boxes and cabinets free from contact with reinforcing steel.
- c. Make metallic conduit and raceways, electrically and mechanically continuous and ground them in accordance with Section 16060.

B. Conduit:

- 1. Run exposed conduit parallel to building lines.

2. Install exposed conduit to avoid interference with other work.
3. Apply lead-free conductive anti-seize compound to threaded-conduit joints.
4. In aboveground indoor locations and electrical rooms, use locknut and nylon- insulated bushing to attach conduit to enclosure.
5. Thread and ream ends of field-cut conduit to remove rough edges. Use bushing at conduit entrance to boxes, cabinets and equipment enclosures.
6. Bends:
 - A. Unless otherwise shown or specified, install conduit bends in accordance with reference codes.
 - B. Bend conduit so that field-made bend is free from cuts, dents and other surface damage.
7. Support conduit during construction to prevent distortion and to ensure independent support.
8. Support horizontal conduit with one-hole pipe straps or individual pipe hangers.
9. Secure conduit supported on multiple-hangers (trapeze) or channel inserts by fasteners suitable for such purpose.
10. Where conduit is attached to masonry surface, use malleable-iron spacers with Style A pipe straps.
11. Support and secure vertical conduit spanning open areas at intervals not exceeding 10 feet.
12. Support conduit above suspended ceiling using applicable specified methods.
13. Install conduit so as to drain moisture to nearest outlet or pull box.
14. Use minimum of 18-inch long liquid-tight flexible-conduit connection for equipment enclosure subject to vibration.
15. Do not use wire for support of conduit and cable.
16. Install expansion fitting in exposed conduit runs longer than 300 feet and where shown.
17. Use only metallic conduit in exposed locations.

C. Outlet, Junction and Pull Boxes:

1. Mount outlet boxes as shown.
2. Keep number of knock-outs to minimum.
3. Clean boxes thoroughly after installation and correct damage to boxes and to finish.
4. Install covers on boxes mounted on walls and ceilings.
5. Measure height of wall-mounted outlet box from finished floor to horizontal centerline of cover plate.
6. Install junction and pull boxes so that covers are readily accessible.

D. Use expansion-bolt anchors to secure equipment to concrete surfaces.

3.2 FILLING OF OPENINGS:

- A. Where conduit and raceway pass through fire-rated walls, ceilings or floors, provide seals to prevent passage of fire and fumes and to maintain integrity of fire-rated structure.
- B. Where openings are provided for passage of conduit and raceways in walls, ceilings or floors, use fire-resistant fibrous-glass safing or similar material to seal unused openings to prevent passage of fire and fumes.
- C. Close unused openings or spaces in floors, walls and ceilings. Plug or cap unused conduit and sleeves.

3.3 IDENTIFICATION:

- A. At end of each run, use stainless steel or aluminum tags, minimum 1-1/2 inch diameter, with stamped markings, minimum 1/4-inch high lettering, and tag holders attached to conduit using a stainless steel band with worm screw clamping device to establish identification of conduits and raceways in accordance with designation of associated equipment served.

3.4 FIELD QUALITY CONTROL:

- A. Test metallic conduit and boxes for electrical continuity. Conduct tests in presence of the Authority Representative.

* * *

END OF SECTION

SECTION 16425

MOTOR STARTERS

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. This section specifies providing motor starters.
- B. Related Work Specified Elsewhere:
 - 1. Grounding and bonding: Section 16060.
 - 2. Circuit breakers: Section 16440.

1.2 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
 - 1. Comply with codes and regulations of jurisdictional authorities.
 - 2. NEC.
 - 3. NEMA AB1, ICS-2, ICS-2.3, 250, KS1.
 - 4. ANSI: Z55.1.
 - 5. ASTM: A47, A653, B187.
 - 6. UL: 845, Electrical Construction Materials Directory
 - 7. ETL: Directory of ETL Listed Products.
- B. The following items to be listed or labeled per referenced UL or ETL directory.
 - 1. Motor starter.
 - 2. Combination starters.
 - 3. Motor circuit protectors.
 - 4. Disconnect (Safety) switches

1.3 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

- A. Shop Drawings:
 - 1. Interconnection wiring diagrams.
- B. Certification.
- C. Operation and Maintenance Manuals.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.
- B. Store motor starters in secure and dry storage facility.

PART 2 - PRODUCTS

2.1 PRODUCTS AND MATERIALS:

- A. General Requirements for Motor Starters:
 - 1. Interchangeability: Equipment of same type, size, rating, functional characteristics and make is to be interchangeable.
 - 2. NEMA ICS-2, ac general-purpose, Class A.
 - 3. Rating: Continuous-current rating suitable for associated motor as shown.
 - 4. Type:
 - a. ½ HP and above up to and including 50 HP: Across-the-line magnetic starter operable on 480-volt, three-phase, 60 Hertz supply.
 - 5. Enclosure:
 - a. Type:
 - (1) For aboveground indoor locations and electrical rooms: NEMA 250, Type I unless otherwise noted on drawings.
 - (2) For mechanical equipment rooms in underground locations: NEMA 250, Type 12.
 - b. Materials:

- (1) Zinc-coated steel sheet: ASTM A653, coating designation G90, minimum thickness 14 gauge.
 - (2) Malleable iron: ASTM A47.
 - c. Finish: Metallic surface cleaned, degreased, primed with zinc primer and finished with light-gray enamel or natural stainless steel color, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.
- 6. Nameplate:
 - a. Nameplate provided on each motor starter and control center in accordance with NEMA ICS, showing manufacturer's name and brand designation, the referenced standard, type, class and rating as applicable.
 - b. Additional functional nameplates for each component as follows:
 - (1) Three-ply, laminated phenolic plates, engraved through black face to white core and attached by means of stainless-steel rivets or screws.
 - (2) Lettering to be vertical gothic using a round or square cutter. V- shaped groove not acceptable.
 - c. Each starter labeled with one-inch wide nameplate showing starter's designation and function in ½-inch high characters.
- B. Across-The-Line Magnetic Starter:
 - 1. Nonreversing as shown.
 - 2. NEMA size: As shown, not smaller than NEMA 1.
 - 3. 480-volt primary to 120-volt secondary control transformer with fuse in the primary circuit.
 - 4. Manual-reset overload relay, one per phase, with the following additional requirements:
 - a. In starter for motors in fan shafts: Magnetic-type sensitive to current.
 - b. In starters for motors in other locations: Thermal-type.
 - 5. Two NO contacts with provision for addition of two NO or NC contacts.
 - 6. HAND/OFF/AUTO selector switch.

C. Motor Circuit Protectors (MCP):

1. NEMA AB1, molded-case quick-make/quick-break, mechanically trip-free switching mechanism with adjustable magnetic trip for instantaneous short-circuit protection.
2. Rating:
 - a. Number of poles: Three.
 - b. Continuous-current rating: As shown, not less than full-load current of motor.
 - c. Voltage: 480-volt, three-phase, 60 Hertz.
 - d. Interrupting rating: As shown.
 - e. Trip range: as necessary to provide maximum protection to associated motor.

D. Combination Starter:

1. NEMA ICS-2, rated 480 volts, three-phase, 60 Hertz.
2. Motor starter: Across-the-line magnetic starter.
3. One 480-volt, three-pole MCP.
4. Externally mounted operating handle with position indicator showing ON/OFF/TRIPPED condition of MCP. Operating handle interlocked for preventing opening and closing of door when MCP is in ON position. Defeater provided to bypass interlock. Provision for padlocking in OFF position.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Install motor starters as shown in accordance with manufacturer's recommendations.
- B. Install conduit in accordance with Section 16130 and the NEC.
- C. Connect power cable and control wire as recommended by manufacturers and as follows:
 1. Make power-cable and control-cable connections to across the-line magnetic starters and combination starters by means of integral mechanical connectors. If such items are not furnished with integral mechanical connectors, make connections using compression connectors in accordance with Section 16125.
- D. Ground motor starter in accordance with Section 16060.

- E. Apply touch-up paint as necessary.

3.2 TESTING:

- A. Furnish necessary equipment and perform the following tests:
 - 1. Test circuits for connections in accordance with wiring diagram.
 - 2. Test to ensure that insulation resistance to ground of nongrounded conductor is in accordance with Section 16060.
 - 3. Test equipment enclosures for continuity to grounding system.
 - 4. Test operation of circuits and controls.
 - B. Submit certified test reports.
- * * *

END OF SECTION

SECTION 16440

CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies furnishing, installing, connecting and testing of circuit breakers.
- B. Related Work Specified Elsewhere:
 - 1. Wire connection accessories: Section 16125.
 - 2. Wire and cable: Section 16120.
 - 3. Grounding and bonding: Section 16060.
 - 4. Raceways, boxes and cabinets: Section 16130.
 - 5. Motor Starters: Section 16425.

1.2 QUALITY ASSURANCE

- A. Codes, Regulations, Reference Standards and Specifications:
 - 1. Comply with codes and regulations of the jurisdictional authorities.
 - 2. NEC.
 - 3. NEMA: AB1.
 - 4. UL: 489 Electrical Construction Materials Directory.
 - 5. ITS: Directory of ITS Listed Products.
- B. Source Quality Control:
 - 1. Each item listed per referenced UL or ITS directory.

1.3 SUBMITTALS

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

1. Shop Drawings.
2. Certification.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Mark each circuit breaker in accordance with applicable reference standard.
- B. Ship each unit securely packaged and labeled for safe handling and to avoid damage or distortion.
- C. Store products in secure and dry storage facility.

PART 2 - PRODUCTS

2.1 PRODUCTS AND MATERIALS

- A. General Requirements:
 1. Interchangeability: Components of the same type, size, rating, functional characteristics and make are to be interchangeable.
- B. Circuit Breaker: NEMA AB1, UL 489, molded-case, bolt-on, quick-make/quick-break, mechanically trip-free switching mechanism, with thermal trip for inverse time-delay overcurrent protection and magnetic trip for instantaneous short-circuit protection. Frame size 100 amperes. Designed to carry continuous rating in ambient temperature of 40C with the following parameters as shown or specified:
 1. Number of poles.
 2. Rated voltage.
 3. Rated interrupting current.
 4. Trip setting.
 5. Frame size.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install new circuit breakers in existing spaces in existing panelboards at locations shown.
- B. Install single and/or multiple-conductor cable in accordance with Section 16120. Connect branch circuit wires as shown. Connect neutral wire of branch circuit to neutral bar in existing panelboard.

- C. Make conduit connections in accordance with Section 16130.
- D. Make power cable connections to circuit breakers and neutral and ground bus bars in panelboards and load centers by means of integral mechanical connectors. If such items are not furnished with integral mechanical connectors, make connections using compression connectors in accordance with Section 16125.

3.2 DIRECTORY OF CIRCUITS

- A. Furnish each existing panelboard and load center where new circuits are utilized using existing spare circuit breakers or new circuit breakers in existing spaces as shown with new legibly printed updated circuit directory located on inside of enclosure.

3.3 FIELD QUALITY CONTROL

- A. Furnish necessary equipment and perform the following tests:
 - 1. Molded-case circuit breakers: Perform pole-to-pole and pole-to-ground insulation resistance tests with 1,000V dc megger. Insulation resistance to be 50 megohms minimum.
 - 2. Test circuit connections in accordance with wiring diagram.
 - 3. Check cable connections to circuit breakers and fused switch unit for tightness.
- B. Submit certified test reports.

* * *

END OF SECTION

SECTION 16601

AUTOMATED ENERGY MANAGEMENT SYSTEM (RTU & Interfaces)

PART 1 - GENERAL

1.01 SUMMARY

- A. This section specifies a complete and operational automated energy management system. AEMS Remote Terminal Units are required at each chiller water air handling units.
 - 1. RTU's (Type 1) at Passenger Stations monitor and control selected lighting, fans, air conditioners, emergency generator unit and other HVAC equipment and electronic relays.
- B. Related Sections
 - 1. Section 15900 - Control Equipment
 - 2. Section 16425 - Motor Starters and Control Centers
 - 3. Section 16130 - Raceways, Boxes and Cabinets
- C. Operating Requirements
 - 1. Designed for continuous, unattended operation to perform:
 - a. Analog, digital and pulse data acquisition.
 - b. Digital control.
- D. Power Requirements
 - 1. 120 Volts AC from Emergency Panel.

1.02 REFERENCES

- A. Code, Regulations, Reference Standards and Specifications
 - 1. Code and Regulation of jurisdictional authorities
 - 2. NEC
 - 3. NEMA 250, ICS-6, WC8, 12
 - 4. ANSI C37.90, Z55.1, C12
 - 5. EIA: RS 232.C
 - 6. ASTM: B138
 - 7. ASHRAE/ANSI : 135P
 - 8. ICEA: S-68-516

1.04 QUALITY ASSURANCE

- A. Qualifications:

1. AEMS equipment manufacturer: Select manufacturer who maintains a full-time organization for installation and service in the Washington DC metropolitan area.
2. AEMS installer: Have instruments, piping and wiring installed by a qualified installer approved by the AEMS equipment manufacturer.

B. Coordination:

1. The Contractor is responsible for the compatibility of the sensor and transmitters with the Authority's Energy Management System Remote Terminal Units (RTU). The RTUs are manufactured by QEI, Inc., model 4151.
2. Have the AEMS installer and the AEMS equipment manufacturer review and modify existing mechanical and electric equipment designs to provide analog telemetering, operational status, and equipment control for items identified in the Interface Points List Requirements in PART 3 of this section.
3. Have AEMS installer coordinate with electrical installers and other contractors as to the exact locations and sizes of new AEMS conduits to be buried in concrete in order to be used by Metro's RTU and AEMS wiring systems.
4. Have AEMS installer coordinate with Related Work listed above.

C. For Code, Regulations, Reference Standards and Specifications, refer to Article 1.02 above.

D. The Contractor shall develop test procedures and obtain AR's approval prior to testing

E. Contractor shall perform progressive tests in accordance with an approved test procedure to verify compliance with specified system performance requirements, including as a minimum, proper component operation, module input and output signal operation and telemetry between equipment sensors and each RTU.

1. Contractor's Quality Assurance Engineer shall witness all progressive testing.
2. All test discrepancies shall be corrected and test reports submitted to the AR prior to scheduling end-to-end testing.
3. Contractor shall notify the AR prior to commencing progressive testing and shall offer the AR the opportunity to witness the testing. Witnessing of any portion of the progressive testing by the Engineer shall not relieve the contractor from responsibility for any portion of follow-on testing.

F. End-to-End Test:

1. The Contractor shall demonstrate the proper functioning of the completed AEMS system including all components and telemetry between each piece of equipment monitored or controlled by the RTU by using a portable

- computer terminal connected to the RTU in the presence of the Engineer.
 2. The AEMS RTU must communicate with the existing Master Terminal at the Maintenance Operation Center.
 3. Each device monitored by a remote sensor shall be monitored from the RTU and operation of the device observed in the field.
 4. Each device controlled by the AEMS system shall be operated with the control command initiated at the RTU.
 5. Simulation of sensors by shorting contacts is to be avoided unless other activation is not possible.
- G. Submit certified test report within ten days after completion of field tests.

1.04 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements in accordance with Division 1 and with the additional requirements as specified for each:
1. Shop Drawings: Show the following as a minimum:
 - a. Proposed changes and revised equipment layouts
 - b. Electrical wiring diagrams and detail control schematics.
 - c. Electrical and mechanical details
 - d. Wire and cable schedules, interconnection diagrams, point assignment charts, and connection diagrams
 - e. RTU point count for various facilities in accordance with Table-1.
 - f. RTU data point assignments are listed in Table-2
 - g. Composite control/status and telemetering sensing equipment schedule.
 2. Product Data: Submit annotated product data for each item of equipment and resubmittal for mechanical or electrical equipment which changes as a result of required modification.
 3. As-Built Documents: Prior Substantial Completion develop an as-built documents as follows:
 - a. As-built drawings of the installation: 11-inch by 17-inch composite interconnection wiring diagram showing the entire energy management interface system. Provide sufficient copies to be stored in each AEMS interface cabinet door pocket.
 - b. Approved copies of each submittal.
 4. Operation and maintenance (O & M) manuals:
 - a. Complete printed operating instructions in manual or handbook form, completely and clearly indexed for ready

- reference during actual operation and for use as text during instruction of personnel.
 - b. Include descriptions of systems, background information and complete procedures for adjustment, calibration, replacement and repair of components in system.
 - c. Make data contained specific for and exclusive to the systems and equipment for the work of this Contract.
 - d. Field test data and reports.
5. Certification:
- a. Certified test results for the specified tests on the Remote Terminal Unit or provide cert b. Certificates from manufacturers verifying that equipment conforms to the specified requirements

1.05 OPERATION AND MAINTENANCE TRAINING:

- A. Operation and Maintenance Training is required only if an alternate vender for the RTU is selected. Operation and Maintenance will not be required if the contractor selects the QUICS 4150 RTU by QEI INC.
- B. Instructional Period: Three consecutive man-days minimum.
- C. Instruction:
 - 1. Train personnel in preventative maintenance on systems and to recognize malfunctions.
 - 2. A minimum of one day devoted to hands-on demonstration of the equipment operation, trouble analysis, repair, adjustment and maintenance.
 - 3. Provide copies of the O & M manuals as specified above for each person being trained. Use these manuals in organizing the instruction. ified test reports on identical unit.

PART 2 - PRODUCTS

2.01 GENERAL:

- A. Provide equipment identified for AEMS with stand-alone controls by the equipment manufacturer.
- B. Auxiliary contacts, modules and data interfaces added to equipment specified in other sections are to be provided by the particular equipment manufacturer or coordinated with the particular equipment manufacturer so as not to void any warranties.

2.02 REMOTE TERMINAL UNIT

- A. Remote Terminal Units (RTU) for Energy Management, QEI INC. Model No. QUICS 4150 or equal.
 - 1. RTU to be compatible with existing master station manufactured by QEI.
 - 2. The contractor shall be responsible for all RTU to master station communication protocols.
 - 3. The RTU manufacturer shall provide a minimum of 1 week of on-site technical support for each RTU supplied.
 - 4. The contractor shall provide all software and hardware required for testing and configuration of the RTU's

- B. Remote Terminal Unit Controller:
 - 1. Based on a microprocessor system, executing programs stored in non-volatile semiconductor memory.
 - 2. Incorporate a unique digital address or identifier. The addressing scheme shall allow operation of several RTUs on a common communications line as well as random access to individual RTU.
 - 3. The message exchange between the Master Station computer and the RTU shall be controlled and supervised by the master station computer. Commands to which the RTU shall respond may include, but not necessarily be limited to, the following:
 - a. Full scan request - Initiates transmission of all measurement and status.
 - b. Selective scan request - Initiates transmission of selected measurement and/or status points.
 - c. Report by exception - Initiates transmission of only those points which have changed since the last transmission. A range of values or deadband, which may be set by the operator, shall determine whether an analog variable shall be transmitted. If the variable has changed by less than the specified deadband since the last reported value, the value shall not be transmitted. If the variable has changed more than the specified amount since the last reported value, the value shall be retransmitted
 - d. Control point select and verify - Command to select a digital control point select.
 - 4. Transmit information only after receiving the proper address from the master station. Design RTU so that it will not respond to the reply messages of other RTUs. Replies of the RTU shall include, but not necessarily limited to, the following:
 - a. Analog and pulse data value message.
 - b. Digital data value message.
 - c. Check back response - Acknowledgment of control point select.
 - d. End message - End of block of data.

5. Provide watchdog timer capable of detecting malfunction of the microprocessor, power source, and communications with the master station. The watchdog timer shall operate independently of the microprocessor logic and clock. When a failure has been detected, the watchdog timer shall inhibit further output of all control signals by the microprocessor and force all output relays to the de-energized state.
6. Provide an internal real-time clock to generate an interrupt to the microprocessor at regular intervals. The internal real-time clock shall be periodically synchronized by the master clock at the master station.

C. Communication Interfaces

1. Provide a serial EIA RS-232C data communication port and a four-wire RJ11 telephone jack for connection to T1 telephone network.
2. Generate required modem control signals and perform level translation of these and data lines to EIA RS-232C standard signal levels.
3. Provide suitable protection equipment to protect the RTU from surges induced on the communications, power or instrumentation lines.
4. Provide a serial communication port for a test/configuration via a portable computer.

D. Instrumentation and Control InterfacesInput/Output Modules:

1. Include installedinput/output modules to accommodate the specified point and spares.
Provide signal conditioning and filtering for each point and include in the modules protection sufficient to meet the surge test requirements specified in ANSI C37.90. "Guide for Surge Withstand Capability (SWC) Tests".
2. Analog Input Modules shall selectively connect analog data points to one or more analog-to-digital (A/D) converters under control of the common logic. The A/D converter shall have sufficient accuracy and conversion rate to satisfy the performance requirements specified previously. Design the analog input modules such that channel crosstalk is eliminated and a common mode rejection ratio of at least 80 dB and a normal mode noise rejection of at least 30 dB at 60 Hz can be achieved.
 - a. Data multiplexing and transducer termination techniques utilized shall not effectively degrade these noise immunity characteristics. Analog input modules shall be capable of accepting the analog output of transducer with a signal output level of 0-1 mA dc.
3. Digital Input Modules:
 - a. Monitor status and alarm points via digital input modules. Provide each input point with an optical isolator to provide electrical isolation between the input and the RTU logic and with filtering to suppress relay contact bounce noise and electromagnetic interference impulses. Digital input modules shall accept dry contact inputs.
4. Digital Control Output Modules:
 - a. Provide separate control relays for each digital output point to operate in

- a. select-check-operate mode as specified by ANSI/IEEE C37.1. Outputs shall be latching continuous output contact closure. Receipt of a point selection address shall cause the RTU to return a verification message to the master station. Execute commands only after the dispatcher has verified that the selected point is the desired point and has issued an execute command for the function to be performed. Control relays shall be installed between the output modules and terminal strips. Contacts shall be rated for 10 Amperes at 120 Volts ac resistive load. Relays shall be factory-mounted and wired.
- 5. Analog Control Output Modules:
 - a. Provide separate D/A converter for each analog output point to operate in a select-check-operate mode as specified by ANSI/IEEE C37.1. Receipt of a point selection address shall cause the RTU to return a verification message to the master station. Execute commands only after the dispatcher has issued an execute command for the function to be performed. The analog output signal level shall be 4-20ma DC. The power source providing the output current shall be supplied internally by the RTU.
- 6. Pulse Input Modules:
 - a. Pulse input modules shall receive pulses in the form of contact open/closure from 3-wire (Form C) pulse initiators. The accumulated count shall not be altered, nor shall counting be interrupted when a count is transferred to the master station. Each counter shall have enough capacity to accumulate the number of pulses expected at the metering point in a 4-hour period without overflow, assuming an average pulse rate of 1 pulse per second. Pulse counter inputs shall be capable of accepting pulse inputs at a rate of 5 pulses per second. The pulse forming voltage, if required, shall be furnished from the RTU circuit.
 - b. The pulse count registers shall not be reset at the end of the interval and shall continue to accumulate and automatically roll over only when they reach maximum count.
- 7. Communications Modules:
 - a. Communications modules shall be provided using an industry standard RS-485 (or RS-232) serial bus to remotely read real-time and min/max measured values, interrogate the event log, reset min/max and kW/kVAR hours and program configuration and any relay set points.
 - b. Isolated Multidrop RS-485/232 Converters shall be provided where daisy chained device communication ports are required.
- 8. Terminal Strips:
 - a. Provide barrier-type terminal strips within the RTU cabinet for all external connections for instrumentation and control signal. Direct

connections to relay terminals will not be allowed.

2.03 SENSORS AND TRANSMITTERS:

- A. General:
 - 1. Power the transmitters by a 24 dc loop power supply located in the AEMS interface cabinet.
 - a. All transmitters shall be powered by 120-volt AC input, 24-volt DC output power supplies located in the AEMS interface cabinets.
 - b. DC power rating shall be capable of supplying the connected load plus 20-percent spare capacity.
- B. Sensors and Transmitters:
 - 1. Room air temperature transmitters shall be an element contained within a cover, suitable for mounting on a wall
 - a. Insulated base temperature range: Minus 20F to plus 120F
 - b. Accuracy of calibrated points: Plus or Minus 0.5F.
 - c. Sensing elements: Platinum wire resistance type.
 - d. Transmitter output signal: 4 to 20 milliamperes DC.
 - 2. Single point duct temperature sensor transmitter:
 - a. Minus 20F to Plus 120F.
 - b. Accuracy of calibrated points: Plus or Minus 1.2F.
 - c. Transmitter output signal: 4 to 20 milliamperes DC.
 - d. Junction box for wiring connections and gasket to prevent air leakage or vibration noise.
 - 3. Pressure transmitters
 - a. Range: Minus 15 to 30 psig
 - b. Accuracy at calibrated span: Plus or Minus 0.20 percent.
 - c. Transmitter output signal shall be 4 to 20 milliamperes DC.
 - d. Source: Foxboro model IGP20 or equal.
 - 4. Liquid Immersion Temperature Sensor Transmitter:
 - a. Stainless steel thermal, sensor and connection head for wiring connections.
 - b. Temperature range: 30F to 70F.
 - c. Accuracy at calibrated span: Plus or minus 0.15 percent.
 - d. Transmitter output signal: Four to 20 milliamperes dc.
 - e. Sensing element: Platinum 100S RTD type.
 - f. Source: Foxboro model 893 or equal.
 - 5. Outside air temperature sensors:
 - a. sensor element shall have a tamper-proof protective

- cover
- b. Range: Minus 20F to Plus 120F
- c. Accuracy: Plus or Minus 1.3F.
- d. Transmitter output: 4 to 20 milliamperes DC.
- 6. Outdoor humidity sensor transmitters:
 - a. Sensor element shall have a tamper-proof shielded cover
 - b. Transmitter output signal: 4 to 20 milliamperes DC output.
 - c. Range: 0 to 100% relative humidity (RH)
 - d. Accuracy: Plus or Minus 5 percent
 - e. Junction box for wiring connections and gasket: NEMA 3R rating.
- 7. Flow Rate Sensors and Transmitter:
 - a. Provide with appropriate orifices and venturis to accommodate flow sensors, pressure differentials, transducers, etc.
 - b. Calibrated in gallons per minute (GPM).
 - c. Transmitter output signal: Four to 20 milliamperes dc.

2.04 Cabinets

- A. RTU Cabinet:
 - 1. Construction: NEMA 12.
 - 2. Accessories: 120 Volt AC GFI type receptacle and 120 Volt AC strip heater.
 - 3. Apply two finish coats, ANSI No. 61, Light Gray, to exterior surface.
 - 4. Paint interior per manufacturer's standard.
 - 5. Fabrication
 - a. Cabinet with fixed side, rear and roof panels, front swing, full hinged door with flush latch operable by screw driver, key, hasp and staple for padlock.
 - b. Provide protective pocket inside front cover with schematic diagram, connection diagram, operating instructions, and layout drawing of control wiring and components within enclosure.
- 6. Terminal Blocks:
 - a. Power Terminals: Rated 30 Amp, 600 Volt with insulating barriers between poles and washer-head binding screws on each pole to accommodate up to 10 AWG wire.
 - b. Signal and Control Terminals: Rated 10 Amps, 300 volts,

modular construction type, screws to accommodate up to 14 AWG wire.

7. Field Wiring Terminals:
 - a. Provide terminal blocks in the RTU to accommodate all field wires including spares.
 - b. The terminal blocks shall not be part of any RTU signal or control components.
 - c. The terminal blocks shall be rated 30 AMPS, 600 volts with insulating barriers between poles and washer-head binding screws on each pole to accommodate up to 10 AWG wire.
8. Nameplate:
 - a. Black laminated plastic composition with permanent white engraved lettering, and beveled edges.
 - b. Fastened to panel using small round-head screws.
 - c. Installed inside cubicle and cabinets with cement.
 - d. Submitted for approval.

B. AEMS Interface Cabinet

1. NEMA 12 stainless steel Hoffman Engineering or equal in accordance with Section 16130 Data Transmission System (DTS) cabinet.
 - a. Terminal Blocks:
 - b. Assembly rail and modular terminals, Weidmuller Terminations Incorporated or equal in accordance with Section 16130 Data Transmission System (DTS) cabinet.
2. Nameplate:
 - a. Black laminated plastic composition with permanent white engraved lettering, and beveled edges.
 - b. Fastened to panel using small round-head screws.
 - c. Installed inside cubicle and cabinets with cement.
 - d. Submitted for approval.

2.05 Marking Tags:

- A. Dekafix 6.5-FS or equal, consecutive vertical, No. 4682.2 or No. 5766.6 as approved.
- B. Group marking carrier with paper marking strip and transparent cover.
 1. Type SCHAT5, Catalog No. 2924.6.
 2. Type ES05, Catalog No. 2937.0.
 3. SST5, Catalog No. 2940.0.

2.06 Raceways, Boxes and Conduit

- A. Provide conduit, raceways, boxes and fittings in accordance with Section 16130

2.07 Control Switch:

- A. For control of chillers, condenser water pumps, chilled water pumps and cooling tower fans:
 - 1. Heavy duty three-position, selector switch with position labeled HAND/OFF/AUTO (HOA).
 - 2. Provide auxiliary contacts on Hand Operated Switches to indicate "HOA Local/Remote" position on Hand Operated Switches provided in accordance with the provisions of other sections.
- B. For control of station ACU fans, AC units, exterior lighting and unit heaters (over 10 KW):
 - 1. Heavy duty three-position selector switch with position labeled HAND/OFF/AUTO (HOA).
 - 2. Provide auxiliary contacts to indicate HOA position.

NOTE: In addition to AEMS interface connections there may also be DTS connection requirements for the same equipment.

2.08 Motor Starters and Contactors:

- A. Provide auxiliary contacts at motor starters and equipment contactors to indicate equipment ON/OFF status. Equipment included are chillers, condenser water pumps, chilled water pumps, cooling tower fans, ACU fans, AC units, exterior lighting and unit heaters.
- B. Provide wiring and interconnection with motor starters and equipment contactors to AEMS interface cabinet.

2.09 WIRING:

- A. Status, Control and Analog:
 - 1. Multicolor cable, No. 14 AWG, UL-listed conductors of 98-percent copper with type XHHW insulation rated 600 volts. Nonmetallic jacket material complying with ICEA S-68-516, NEMA WC8, free of PVC or PVC-based compounds.
 - 2. Jacket: Chlorosulfanated polyethylene, crossed-linked polyolefin, or heavy duty neoprene.
 - 3. Use shielded twisted pair cable for analog inputs and outputs.
 - 4. Wiring to escalator PLC's shall conform with PLC manufacturer's requirements with plenum rated jacket free of PVC or PVC based components.

2.10 Electronic Power Meter

- A. ANSI C37.90.1 and ANSI C12.

2.11 Spare Parts:

- A. In accordance with special conditions and the following:
 - 1. Provide 2 spare of each type of circuit card, 2 power supplies, and 2 modems for each type used. Provide touch up paint in 1-quart container.

PART 3 - EXECUTION

3.01 SOURCE QUALITY CONTROL

- A. Design and Production Tests: Perform and submit in accordance with the General Provisions, certified test results for the tests on each unit of Remote Terminal Unit supplied under this contract.

3.02 INSTALLATION

- A. RTUs shall be delivered and installed as shown in accordance with approved shop drawings at the following facilities:
 - 1. Traction Power Substations
 - 2. Passenger Stations
 - 3. Chiller Plants
- B. The Contractor shall terminate all wiring on terminal strips in accordance with approved shop drawings and interconnection diagrams.
- C. Perform work in accordance with the NEC.
- D. Terminate interface points in the AEMS interface cabinet. Wall-mount each AEMS interface cabinet in the room associated with the equipment.
- E. Raceways Boxes and Cabinets:
 - 1. Install conduit, raceways, boxes, fittings in accordance with Section 16130 as necessary to facilitate connections in accordance with Table 2
 - 2. Install wall mounted AEMS interface cabinets as necessary in the vicinity of equipment other than AC switchgear, chillers or Traction Power equipment located in the same room where the RTU is installed.
 - a. Label the interface cabinet as the AEMS INTERFACE CABINET.
 - b. Install AEMS interface cabinets at locations in accordance with approved shop drawings.
 - 3. Install raceways, wiring and terminations between the interface boxes and the RTU unit in the AC switchgear room.
 - 4. Arrange terminations in AEMS interface cabinets in a sequence to facilitate maintenance. Terminations shall comply with the following

requirements:

- a. Terminal strips shall be identified with markings tags as TB-1, TB-2, TB-3, ext. as required from left to right.
- b. Terminals shall be identified consecutively on the various terminal strips from top to bottom and from left to right.
- c. Terminations for equipment shall be grouped by equipment identification with control functions located on top and indication functions located on the bottom within the grouping.
- d. Terminations for various equipment of the same type/classification such as EF-1 and EF-2 shall be terminated on consecutive terminals from top to bottom in ascending equipment number sequence.
- e. Spare terminals shall be concentrated in one area of the terminal strip to the extent possible.

F. Wiring:

1. Use shielded twisted pair cable for analog input and control output signals and multi-conductor cable for all other functions.
2. Install wiring for AEMS interface circuits for all points identified for branch circuits to power supplies located in selected AEMS interface cabinets and for circuits from power supplies to sensors and transmitters in accordance with the following requirements:
 - a. Terminate shield drain wire of two-conductor, shielded twisted-pair instrumentation cable on a terminal strip in the AEMS interface cabinet located directly below the associated two conductors for the cable. Drain wire shall not be grounded at the AEMS interface cabinet. (Drain will be grounded at the RTU)
 - b. Terminate twisted pair instrumentation cables for analog circuits on terminal strips that are separate from terminal strips used to terminate non-analog circuits.
 - c. Install twisted pair instrumentation cables for analog circuits in conduits that are separate from conduits used for non-analog circuits.

G. Ground RTU, AEMS interface cabinets and power supplies in accordance with Section 16060

H. Install auxiliary contacts as required for implementation of AEMS interface connections in contactors and starters specified in Section 16145 and Section 16425

I. Install thermostats and sensors at locations indicated on drawings with top of thermostat 5'-0" above finished floor.

J. Connections to escalators shall be via a single daisy-chained digital communications link between each escalator's PLC and the AEMS RTU

- K. Wiring terminations between the chiller and the AEMS located in the chiller plant may be made directly to the AEMS without the requirement for an interface cabinet.
- L. Wiring between the RTU in the traction power substation and traction power equipment may be made directly to the RTU without the requirement for an interface cabinet.
- M. Wiring in the AC switchgear room between the switchgear and the RTU may be made directly to the RTU without the requirement for an interface cabinet. Connections to mechanical equipment in the AC switchgear room shall require an interface cabinet.
- N. At locations where there is a combined AC switchgear room / traction power substation in the same room, the requirement for separate RTU's for each shall not be waived.

3.03 FIELD TESTING:

- A. The Contractor shall perform polarity and continuity test on all interconnection wiring.
- B. The Contractor shall perform system start-up for each RTU in the presence of the manufacturing representatives. The manufacturing representative shall verify correct operation of each input/output data card using a simulated master control interface test unit. Additional checkout shall be made to verify wiring terminations, modem operation, power supply operation and CPU operation.
- C. The Contractor shall label all wiring terminations to reflect the connection points.
- D. The Contractor is responsible for testing all RTU input signals to verify correct status and telemetry signal levels. A test data sheet shall be developed for each RTU/AEMS
Interface Cabinet which list all I/O signal points. The data sheet shall be submitted as part of the Contractors test plan. The Contractor shall submit a list of discrepant I/O signal points to the Engineer. I/O equipment supplied under this contract that is not reporting properly shall be corrected and retested. The Contractor shall submit a discrepancy report for all I/O points indicating problems found and required action.

Table 1

RTU POINT COUNT

RTU Point	<u>RTU Type I</u>
Analog input:	

3.	0-1 mA:	16
4.	4-20 mA:	16
	Status input:	40
	Control input:	
1.	Latching:	16
2.	Momentary	16
	Analog output, 4-20 mA:	0
	Pulse accumulator:	8

TABLE 2

PASSENGER STATION DATA POINTS		
ANALOG DATA POINTS (4- 20 mA)		
DATA POINT	FUNCTION	TYPE
1	ACU-1,2,3 Chilled Water Supply Temperature	deg F
2	ACU-1,2,3 Chilled Water Return Temperature	deg F
3	ACU-1,2,3 Chilled Water Flow	GPM
4	ACU-1,2,3 Supply Air Temperature	deg F
5	ACU-1,2,3 Return Air Temperature	deg F
6	Station Ambient Temperature	deg F
7	ACU-1,2,3 Return Air Humidity	percent
EQUIPMENT STATUS POINTS (Contact Closure)		
1	ACU-1,2,3 Fan	on/off
HOA SWITCH STATUS POINTS (Contact Closure)		
1	ACU-1,2,3 Fan	Auto/Hand

CONTROL POINTS (Contact Closure)		
1	ACU-1,2,3 Fan	on/off

* * *

END OF SECTION

