WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
600 FIFTH STREET, NW
WASHINGTON, DC 20001

Tender Number: IFB-FQ17162/KKB

Date of Issuance: August 4, 2017

Tender Due Date: August 30, 2017

ADDENDUM NO. 01
TO
INVITATION FOR BIDS
Replacement of Chiller and Cooling Towers at Three (3) Metro-Rail Stations: DC AND MD

TO WHOM IT MAY CONCERN:

The Invitation for Bids for Bid Documents accompanying IFB-FQ17162/KKB requesting tenders for above solicitation are herewith changed in part as listed below. The changes are bolded and denoted with ## signs. This addendum includes Divisions 02-03, 05, 07, 09, 15 & 16.

1. VOLUME 1-SPECIFICATIONS: 00-03, 05, 07, 09, 15 & 16

   At the end of Volume-1, Divisions 00-01, Section 01820, Page 6, add the attached Divisions 02-03, 05, 07, 09, 15 & 16

2. There are no further changes.

3. THE SOLICITATION PROVISIONS ENTITLED "SOLICITATION AMENDMENT: IS APPLICABLE TO THIS ADDENDUM. THE CHANGES SET FORTH ARE HEREWITH INCORPORATED INTO THE ABOVE CITED SOLICITATION. THE HOUR AND DATED SPECIFIED FOR RECEIPT OF TENDERS IS NOT EXTENDED AND WILL REMAIN AUGUST 30, 2017 AT 2:00 PM EST.

4. Acknowledgement: Bidders are required to acknowledge receipt of this addendum on Bid Form in the space provided. Failure to acknowledge all addenda may cause the tender to be considered non-responsive to the invitation, which may cause its rejection.

Issued By: _____
Norie A. Calvert, Contracting Officer, Office of Procurement and Materials

Washington Metropolitan Area Transit Authority
600 Fifth Street, NW
ashington, DC 20001
202/962-1234

Replacement of Chillers and Cooling Towers at Three Metro-Rail Stations

CWPE05 Georgia Avenue-Petworth
CWPB11 Glenmont
CWPC03 Farragut West

For

Washington Metropolitan Area Transit Authority

Contract No.: FQ17162

TECHNICAL REQUIREMENTS

Volume 1, Specifications, Divisions 02-03, 05, 07, 09, 15, and 16

Addendum No. 01

SECTION 2

SPECIAL CONDITIONS

SECTION 2

APPENDIX C

REPLACEMENT OF CHILLERS AND COOLING TOWERS AT THREE METRO-RAIL STATIONS
CWPE05 - GEORGIA AVENUE-PETWORTH, CWPB11 - GLENMONT, CWPC03 - FARRAGUT WEST

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I

SECTION 3

TECHNICAL PROVISIONS

SECTION 3

TECHNICAL PROVISIONS
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SECTION 01000

SCOPE OF WORK

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies the furnishing and installation of the chillers, cooling towers, refrigerant leak detection systems and chilled/ condenser water system accessories at CWPE05 Georgia Ave-Petworth, CWPB11 Glenmont and CWPC03 Farragut West chiller plant locations. The Contractor shall furnish all labor, tools, permits, coordination, 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. **CWPE05 – GEORGIA AVE-PETWORTH CHILLER PLANT**

   a. Remove and dispose one water cooled chiller as indicated on the drawings. Removal shall include the chiller, chiller supports, starter, wiring, conduit, disconnect, all applicable AEMS sensors, and controls.
   b. Remove and dispose of one cooling tower as indicated on drawing. Removal shall include the cooling tower fan, fan motors, belts, wiring, conduit, disconnects, all applicable 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 of chilled water pumps and condenser water pumps. Removal shall include the pumps, pump motors, pump supports, vibration isolators, immediate piping and valves, starters, wiring, conduit, disconnects, all AEMS sensors, and controls, if applicable. Removal shall also include air separators and the expansion tanks
   e. Remove and dispose of existing chilled water and condenser tower water treatment components.
   f. Provide and install one new water cooled chiller. Installation shall include all related pipe fittings, valves, insulation, air separator, expansion tank, piping support, vibration isolation, unit mounted starter, disconnects, conduit, wiring, and controls.
   g. Provide and install one new cooling tower with direct drive assembly and mounting hardware. Fan motor shall have frequency drive controller. Cooling tower shall include a complete working platform and ladder system for service.
   h. Provide and install two new chilled water pumps with variable frequency drive motors and two new condenser water pumps with variable frequency drives. New installation shall include the pumps, inverter rated motors, pump supports, vibration isolators, immediate piping, flexible connectors and valves and controls.

i. Provide integration of the pumps and tower fan variable frequency drives with the chiller control system. Pump control shall be equipped with VFDs and shall have operational control and status modes with alarm monitoring. 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 be equipped with VFDs and shall have operational control, load modulation, and status modes with alarm monitoring. Modulation will be controlled by chiller mounted condenser water temperatures. Sequence of operations shall be included.

j. Provide and install a refrigerant gas leak monitoring system utilizing Sherlock 402-4 control module and Sherlock Refrigerant Gas Sensor for R134a.

k. Provide and install one chilled water fan coil unit connected to the chilled water supply and return system to serve the chiller plant mechanical equipment room. Provide and install one new AEMS sensor and controls.

l. Provide and install a new chilled water and condenser water treatment system. 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 capable to accept the input probes and control the chemical injection. Controller shall include a RS485 communications card.

m. Provide and install one Chiller Plant Monitoring Panel. Chiller Plant Monitoring Panel shall include Automatic Direct Productivity 3000 PAC Controller, Modbus capable Input and Output Cards, etc.

n. Provide and install communications wiring in galvanized rigid conduit (GRC) from flow meter monitoring panel to the Chiller Control Panel, utilizing Belden 89842 Multi-Conductor – Low Capacitance Computer and Computer POS Cable or equivalent.

o. Provide and install refrigerant detection and alarm system and interface with exhaust fans and fan controller to integrate with the refrigerant monitoring panel and chiller plant monitoring panel.

p. Provide and install one chilled water and one condenser water flow monitoring systems.

q. 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.

r. 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.

s. Provide, install and coordinate with WMATA on a new ModBus communication cards and control, Microtech II, on new chiller and cooling tower to allow for remote monitoring and control of equipment.

t. Repair and/or modify existing housekeeping pads as needed for new chiller and pumps.

u. Remove rust and paint the existing cooling tower support/steel framing on cooling tower structural support.

v. Provide Maintenance and Repair and Testing and Operations manuals for all systems and components, individually for each location.

w. Train WMATA personnel on system operations and maintenance at the manufacturer's facility.

x. Test and Balance the water system in accordance with NEBB or AABC.

3. **CWPB11 – GLENMONT CHILLER PLANT**

a. Remove and dispose one water cooled chiller as indicated on the drawings. Removal shall include the chiller, chiller supports, starter, wiring, conduit, disconnect, all applicable AEMS sensors, and controls.

b. Remove and dispose of one cooling tower as indicated on drawing. Removal shall include the cooling tower fan, fan motors, belts, wiring, conduit, disconnects, all applicable 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 of chilled water pumps and condenser water pumps. Removal shall include the pumps, pump motors, pump supports, vibration isolators, immediate piping and valves, starters, wiring, disconnects, all AEMS sensors, and controls, if applicable. Removal shall also include air separators and the expansion tanks
e. Remove and dispose of existing chilled water and condenser tower water treatment components.
f. Provide and install one new water cooled chiller. Installation shall include all related pipe fittings, valves, insulation, air separator, expansion tank, piping support, vibration isolation, unit mounted starter, disconnects, conduit, wiring, and controls.
g. Provide and install one new cooling tower with direct drive assembly and mounting hardware. Fan motor shall have frequency drive controller. Cooling tower shall include a complete working platform and ladder system for service.
h. Provide and install two new chilled water pumps with variable frequency drive motors and two new condenser water pumps with variable frequency drives. New installation shall include the pumps, inverter rated motors, pump supports, vibration isolators, immediate piping, flexible connectors and valves and controls.
i. Provide integration of the pumps and tower fan variable frequency drives with the chiller control system. Pump control shall be equipped with VFDs and shall have operational control and status modes with alarm monitoring. 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 be equipped with VFDs and shall have operational control, load modulation, and status modes with alarm monitoring. Modulation will be controlled by chiller mounted condenser water temperatures. Sequence of operations shall be included.
j. Provide and install a refrigerant gas leak monitoring system utilizing Sherlock 402-4 control module and Sherlock Refrigerant Gas Sensor for R134a.
k. Provide and install one chilled water fan coil unit connected to the chilled water supply and return system to serve the chiller plant mechanical equipment room. Provide and install one new AEMS sensor and controls.
l. Provide and install a new chilled water and condenser water treatment system. 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 capable to accept the input probes and control the chemical injection. Controller shall include a RS485 communications card.
m. Provide and install one Chiller Plant Monitoring Panel. Chiller Plant Monitoring Panel shall include Automatic Direct Productivity 3000 PAC Controller, Modbus capable Input and Output Cards, etc.
n. Provide and install communications wiring in rigid conduit from flow meter monitoring panel to the Chiller Control Panel, utilizing Belden 89842 Multi-Conductor – Low Capacitance Computer and Computer POS Cable or equivalent.
o. Provide and install refrigerant detection and alarm system and interface with exhaust fans and fan controller to integrate with the refrigerant monitoring panel and chiller plant monitoring panel.
p. Modify existing ventilation system ductwork.

q. Provide and install one chilled water and one condenser water flow monitoring systems.
r. 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.
s. 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.
t. Provide, install and coordinate with WMATA on a new ModBus communication cards and control, Microtech II, on new chiller and cooling tower to allow for remote monitoring and control of equipment.
u. Repair and/or modify existing housekeeping pads as needed for new chiller and pumps.
v. Repair and/or modify existing concrete pad and support for new cooling tower.
w. Provide Maintenance and Repair and Testing and Operations manuals for all systems and components, individually for each location.
x. Train WMATA personnel on system operations and maintenance at the manufacturer's facility.
y. Test and Balance the water system in accordance with NEBB or AABC.

4. **CWPC03 – FARRAGUT WEST CHILLER PLANT**

a. Remove and dispose of three water-cooled chillers. Removal shall include the chiller, chiller supports, starter, wiring, conduit, disconnects, all AEMS sensors, and controls.
b. Removal of the chillers 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 and condenser water pump's #1, 2, 3, and 4. Removal shall include the pumps, pump motors, pump supports, vibration isolators, immediate piping connections, valves, motor starter, wiring, conduit, disconnects, all AEMS sensors, and controls.
d. Provide and install three new water cooled chillers with an in-kind replacement. Installation shall include all related pipe fittings, valves, insulation, vibration isolation, unit mounted starter, disconnects, conduit, wiring, and controls. Replace all valves on the chiller side from chilled water/ condenser water return to chilled water supply and as shown on the drawings.
e. Provide and install new chilled water pumps #1, and 2 and condenser water pump #1, 2, 3, and 4. New installation shall include the pumps, inverter rated motors, pump supports, vibration isolators, immediate piping, flexible connectors, strainers, valves, and controls.
f. Provide and install two new chilled water pump motor variable frequency drives (VFDs), four new condenser water pump motor variable frequency drives, and all associated disconnects, conduit, power, controls and control wiring.
g. Provide integration of the pumps and tower fan variable frequency drives with the chiller control system. Pump control shall be equipped with VFDs and shall have operational control and status modes with alarm monitoring. 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 be equipped with VFDs and shall have operational control, load modulation, and status modes with alarm monitoring. Modulation will be controlled by chiller mounted condenser water temperatures. Sequence of operations shall be included.

h. Provide and install chilled water and condenser water treatment systems, including piping, water chemical sensors, and controls. Water treatment sensors shall include a 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 and Modbus capable Input and Output Cards.
i. Existing third party water treatment system for the chilled and condenser water systems to remain. The water treatment system presently has web based remote monitoring, control, and reporting.
j. Provide and install a new expansion tank and air separator on the chilled water return loop. Existing tank support shall be reused.
k. Provide and install outdoor air temperature and relative humidity and space 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.
l. Provide and install communications wiring in galvanized rigid conduit (GRC) from flow meter monitoring panel to the Chiller Control Panel, utilizing Belden 89842 Multi-Conductor – Low Capacitance Computer and Computer POS Cable or equivalent.
m. Provide and install refrigerant detection and alarm system and interface with the exhaust system.

    1) Remove exhaust fans and replace/ relocate with one exhaust fan and associated ductwork.
    2) Remove power wiring and conduit for EF-1 and EF-2.
    3) Remove existing ventilation control system.
    4) Remove existing refrigerant monitoring control system, sensors, and devices.
    5) Provide and install new Sherlock 402 Refrigerant Monitors.
    6) Provide and install new Sherlock refrigerant sensors for R-134A.
    7) Provide and install one strobe light at the front entrance doors to the chiller room.
    8) Provide and install one strobe light in the chiller room.
    9) Provide and install an audible alarm inside the chiller room.
    10) Provide and install any necessary power wiring.
    11) Provide and install fan, ventilation controller fan controller to integrate with the refrigerant monitoring panel and chiller plant monitoring panel, motor operated dampers, ductwork, grilles and sensors.
    12) Provide and install VFD, conduit and associated wiring for new exhaust fan.

n. Provide and install one chilled water and one condenser water flow monitoring system.
o. Provide and install chilled water air handling unit for the equipment space. Replace outside air intake louver and dampers.
p. Provide and install any other equipment and components required by chiller and cooling tower manufacturers to ensure a satisfactory performance of the manufacturers' system.
q. Provide and install new Modbus communication cards and control, Microtech II, on replacement chiller to allow for remote monitoring and control of equipment.
r. Repair and modify existing housekeeping pads as needed for replacement chiller and pumps.
s. Provide and install components for cooling towers as listed.

    1) Remove and dispose of cooling tower fan motor's, related starters and controls. Modify existing cooling tower Control Panel to adopt new variable frequency drive controller(s) which is installed at the Chiller Plant Room.
    2) Remove and dispose of existing tower water treatment components.
    3) Provide and install three cooling tower inverter-rated fan motor.

4) Replace the belt-driven fan drive assembly, include belts, sheaves and mounting hardware for the Cooling Tower.
5) Replace the motor of the Cooling Tower fan's (three). Motor shall be inverter type to match the variable frequency drive controller, including disconnects, conduit, power and control wiring.
6) Integrate tower fan VFD drive with the chiller control systems. Tower fan control features shall include soft-start, load modulation, and off modes. Modulation will be controlled by chiller mounted condenser water temperatures.
7) Replace existing air intake louvers and inside fill on each cooling tower.

t. Remove and replace lighting with energy efficient fixtures within the chiller plant room. Comply with current code.
u. Demolish abandoned conductivity monitoring system equipment.
v. Demolish abandoned EMT conduits within the chiller plant room.
w. Demolish abandoned flow sensor system, differential pressure switch, old water treatment system and chiller disinfecting system.
x. Provide and Install a new utility sink, water heater, backflow preventer and permanent eye wash station.
y. Provide new unit heaters for space heating.
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 at the manufacturer's facility.
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. Equipment Warranty:

1. All major equipment shall be provided with five year service warranty, which includes an annual scheduled service maintenance, on entire parts and labor.
2. All major equipment manufacturer shall have a local factory service within 100 miles of jobsite for regular maintenance.

D. Maintenance contracts for all major equipments and control system shall be included. Period of maintenance requirement shall be coordinated with owner.

E. Reference Codes and Specifications:

1. Codes and regulations of the District of Columbia.
2. Code and regulations of Maryland.
3. Discipline specific 2015 International Code Council.

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.
c. Provide manufacturer’s product literature for all installed items.

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:

1) Description of system and components.
2) Schematic diagrams of electrical, plumbing, and drainage systems.
3) Manufacturer's printed operating and maintenance instructions.
4) List of original manufacturer's parts, including suppliers' part numbers and cuts, recommended spare parts, stock quantity, and local parts and service source.

a) Assemble and provide four (4) copies of manual, per location, in 8-1/2 by 11 inch format. Foldout diagrams and illustrations are acceptable.
b) Provide electronic files for manual using MSWord 2016 for text and Auto CAD Latest Version /Group 4 (PDF) 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 (regular working hours) 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, operation 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 15625.

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 called out on drawings and per manufacturers instructions.

D. All Cooling towers shall be per 15640.

E. All other ancillary components for a complete functional system shall be per corresponding specifications and drawings.

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 02220.

C. All field painting shall be performed as specified in Section 09920.

D. HVAC motors and variable frequency drives shall be selected and installed as specified in Section 16225 and 16480.

E. All mechanical equipment and piping shall have vibration isolation as specified in Section 15070.

F. All mechanical equipment and piping shall be identified as specified in Section 15075.

G. All equipment and piping insulation shall be selected and installed as specified in Section 15080.

H. Water treatment system shall be selected and installed as specified in Section 15186A.

I. All piping shall be selected, installed and tested as specified in Section 15205.

J. All air conditioning systems shall be selected, installed and tested as specified in Section 15733A.

K. All heating equipment shall be selected, installed and tested as specified in Section 15765.

L. All ductwork shall be selected, installed and tested as specified in Section 15810.

M. All fans shall be selected, installed and tested as specified in Section 15830.

N. Chiller plant monitoring shall be selected and installed as specified in Section 15900A.

O. All systems shall be tested and balanced in accordance with Section 15950.

P. All wiring and equipment shall comply with grounding and bonding requirements as specified in Section 16060.

Q. All wire and cable shall be selected, installed, and tested as specified in Section 16120.

R. All raceways, boxes and cabinets shall be selected, installed and tested as specified in Section 16130.

S. All motors shall be selected, installed and tested as specified in Section 16225 except as noted above. All motor enclosures shall be rated “water-proof”.

T. All motor starters and control center components shall be installed and tested as specified in Section 16425.

U. 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.

1. Chillers: Provide five (5) year parts, labor and refrigerant warranty and routine service requirement for the new chillers during the warranty period.
2. Cooling Tower: Provide five (5) year parts, labor and routine service requirement for the new cooling tower during the warranty period.

3.07 PERSONNEL

A. 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

A. 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

A. 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

A. 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

A. 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 as both water cooled and air-cooled chillers 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 both water cooled and air-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 and air side of air 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.

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 02220.

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 shall be coordinated by the contractor with WMATA during construction.
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.

1.02 SUBMITTALS (NOT USED):

1.03 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

3.01 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.

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

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

3.04 CANOPIES, AWNINGS AND GRILLES (NOT USED):

3.05 VAULTS (NOT USED):

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

3.07 SIGNS, FLAGPOLES, RAILINGS AND FENCES:

A. Signs:

1. All signs must comply with WMATA standards.

3.08 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.

3.09 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 02220

DEMOLITION

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies demolition work.

B. Definitions:

1. Demolition: Complete removal and disposal of existing facilities from areas to be cleared.
2. Existing facilities include, but are not restricted to, buildings and other utility facilities located in the area.

1.02 SUBMITTALS:

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

1. Certification:

a. Submit copy of request to utility companies owning or agency controlling services and appurtenances affected by demolition work for discontinuance of services along with certificates of severance.

2. Documentation:

a. Demolition permit from the jurisdictional agency or owner.
b. Permits and releases from each owner of property where demolition debris will be deposited absolving the Authority of responsibility in connection with such disposal.

1.03 QUALITY ASSURANCE:

A. Submit Codes, Regulations, Reference Standards and Specifications:

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

1.04 JOB CONDITIONS:

A. 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.

B. 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.

C. Protection and Restoration:

1. Prevent damage to pipes, conduits, wires, cables and structures above and below ground which are not designated for removal. Repair or replace damaged items.

D. For Cooling Towers located on a commercial property other than WMATA, contractor shall coordinate any demolition work with the building management.

PART 2 – PRODUCTS

(NOT USED)

PART 3 – EXECUTION

3.01 PRESERVATION OF REFERENCES:

A. Prior to removal, record location and designation of survey markers and monuments located within demolition area. Store markers and monuments during period of work. Restore survey markers and monuments upon completion of work.

3.02 DISPOSAL:

A. Remove debris resulting from demolition work to locations outside Authority's right-of-way.

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. Do not burn debris at demolition site.

END OF SECTION

SECTION **03100**

CONCRETE FORMWORK

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies formwork for concrete structures and other facilities.

B. Related work specified elsewhere:

1. Concrete reinforcement: Section 03200.
2. Cast-in-place structural concrete: Section 03300.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of the jurisdictional authorities.
2. ACI: 347, Publication # 4
3. Western Woods Producers Association: Western Lumber Grading Rules.
4. CE: CRD-C 572.
5. AASHTO: M153.
6. ASTM: D1056, D1149, D1692.
7. APA: HDO Plywood Exterior Grade.
8. U.S. Product Standard: PS 1

B. Responsibilities:

1. Design and construction of formwork is the responsibility of the Contractor, subject to review by the Engineer.

C. Design Criteria:

1. Design formwork for vertical loads and lateral pressures in accordance with ACI 347.
2. Design formwork system which is adequately braced and has adequate strength and stability to ensure finished concrete within the specified tolerances.
3. When necessary to maintain the specified tolerances, design camber into the formwork to compensate for anticipated deflection and creep due to the weight and pressure of the fresh concrete, pre-stressing forces and construction loads.

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. Working Drawings:

a. Include details of form types, methods of form construction and erection, design computations and location of form joints and form ties, location and dimensions of blockouts and openings in structure, and embeds.

2. Samples:

a. Snap-off form ties: Two.

3. Certification:

a. Manufacturer's certificates.
b. Certified test reports of specified concrete tests.

4. Documentation:

a. Calculations: Early form removal calculations as specified certified by a professional engineer registered in the area where the work is to be performed. Submit in advance for obtaining approval prior to form removal.

PART 2 – PRODUCTS

2.01 MATERIALS:

A. General:

1. Wood forms:

a. All framing lumber stress-graded.
b. Lumber in direct contact with concrete, dressed on at least the contact side, with dressed or tongue-and-groove edges; other lumber may be dressed or rough.
c. Where vertical board finish is shown, or specified, use the following:

1) Form board: Tongue-and-groove, Number 1 Common or better, Ponderosa or White pine, in accordance with the Western Lumber Grading Rules book published by WWPA (not the Southern Pine Inspection Bureau grading rules), one-inch nominal thickness, four-inch nominal width, groove S2S milled or beveled one side only and center matched with 45-degree beveled edges to produce sharp V-shaped 3/8-inch wide in concrete. Four-inch tongue-and-groove boards to be toenailed at edge or face-nailed to backer board.
2) Smooth concrete: Tongue-and-groove, square cut unturned edges, Number 1 Common or better, Ponderosa or White pine, in accordance with the Western Lumber Grading Rules book published by WWPA (not the Southern Pine Inspection Bureau grading rules), one-inch nominal thickness, four inches nominal width, S2S and center-matched.

2. Plywood forms:

a. APA grade-marked:

1) B-B Plyform Exterior grade Group I or II for unexposed finished concrete.

b. APA High-Density Overlay (HDO) plywood;

1) B or better face veneer Exterior grade Group I for exposed to public view finished concrete.

c. USPS: PS 1

3. Hardboard:

a. For concrete not exposed to public view: tempered, smooth-one-side (S1S) panels not less than 3/16-inch thick, in accordance with AHA IS 1.

4. Form ties:

a. Factory-fabricated, snap-off metal type, of adequate design to minimize form deflection and preclude concrete spalling upon removal.
b. Fabricated so that set-back in concrete is such that portion of tie remaining after snap-off and removal of exterior portions is at least 1-1/2 inches below concrete surface.

5. Form release agent: Chemically reactive liquid product that will not bond with, stain, or impair concrete surfaces. Follow form panel manufacturers approved product and recommendations for application. Agents containing castor oil are prohibited
6. Chamfer strips: Except where other sizes are shown, 3/4-inch by 3/4-inch triangular fillets milled from clear, straight-grain pine, surfaced-each-side, or extruded-vinyl tape.
7. Miscellaneous preformed strips for reveals, rustications and similar joints: Fabricated of wood, metal, plastic or other approved material formed to cross sections shown.
8. Conduit: Schedule 40, black steel pipe, butt-welded as specified in Section 15205.
9. Bonding adhesive: As recommended by manufacturer of premolded elastic filler.

PART 3 – EXECUTION

3.01 CONSTRUCTION AND WORKMANSHIP:

A. Concrete finishes and usage locations of various types of forms and form lining: As shown or specified.

B. Unless otherwise shown for concrete surfaces exposed to public view, use HDO Plywood in largest practicable continuous panels to produce plane, smooth surface free from grain imprint, patchmarks, and discoloration.

C. Construct adequately braced formwork so that resulting concrete surfaces conform to specified tolerances.

D. Brace forms, falsework and centering adequately to retain forms in position as shown on approved working drawings.

E. Provide mortar-tight forms of wood, plywood, or other approved materials which conform to shapes, lines and dimensions shown and produce smooth surface without fins and projections.

F. Where shown, or directed because of lagging or form irregularity, and where concrete surfaces will not be exposed to public view, line inner form surfaces with hardboard as follows:

1. Use widest available width of hardboard.
2. Line areas less than four feet wide with single-width piece of hardboard.
3. Offset lining joints from those in backing.
4. Fasten securely to backing with galvanized or aluminum nails driven flush.

G. Forms shall be clean of any rust, molds, concrete scale. etc.

3.02 FIELD QUALITY CONTROL:

A. Allowable Tolerances:

1. Construct elements except concrete linings of tunnels to meet allowable tolerances of dimensions, elevations and positions shown and specified in Section 03300.

3.03 COATING FORMS:

A. Lightly coat form panels with chemically reactive release agent prior to initial concrete placement and before each subsequent placement.

B. Do not allow excess coating material to stand in puddles in forms nor to come into contact with concrete against which fresh concrete is to be placed.

C. Coat with release agent bolts and rods that are to be completely removed or to be free to move.

3.04 EMBEDDED ITEMS:

A. Ensure that items to be embedded in concrete are free from oil and foreign matter that would weaken bond of concrete to such items.

B. Install in formwork inserts, anchors, sleeves and other items specified elsewhere. Close ends of conduits, piping and sleeves embedded in concrete with caps or plugs.

C. Install continuous dovetail-anchor slots where shown.

D. Complete tests on piping and other items before starting concrete placement.

E. Before depositing concrete, check location and support of piping, electrical conduits and other items which are to be wholly or partially embedded.

3.05 OPENINGS AND RECESSES IN CONCRETE:

A. Provide openings and recesses; place sleeves furnished by other trades.

3.06 JOINTS:

A. Unless otherwise directed, make contraction, expansion and construction joints only where shown. Where concrete will be exposed to public view, use largest practicable size sheets to minimize joints.

B. Form keyways as shown.

1. Continue reinforcing steel and wire fabric across joints unless they are shown as being free to move.

C. Make maximum distance between transverse contraction joints 50 feet or as shown, as measured along centerline of track on tangent alignment.

D. Install premolded joint filler at locations shown. Extend filler from bottom of concrete up flush to finish concrete surface or hold down below finish surface as shown.

1. Make splices in premolded filler in manner to preclude penetration of concrete between joint faces.

E. Where premolded joint filler is held below finish concrete face, install in the form a water-soaked wood strip of dimensions shown, to form, after removal, proper size slot to receive sealant compound.

3.07 WATERSTOPS:

A. Install waterstops in construction joints below grade and where shown. Use six-inch minimum width, except use nine-inch minimum width in tunnel structures, or as shown.

B. Support and protect that portion of waterstop which extends beyond bulkhead, during placing of concrete and subsequent removal of forms.

C. Position waterstops so as to clear reinforcement. Ensure that the waterstop does not get misaligned or misplaced during concreting.

D. Make field splices by heat-sealing square cut ends of waterstop using hot metal plate or thermostatically controlled electric-heating iron designed for such purpose. Join ends when material becomes molten, maintaining continuity of ribs and bulbs; allow to cool before stressing.

E. Make field splices to develop water tightness equal to that of unspliced material and tensile strength of not less than 50 percent of unspliced material. Have 90-degree splices and as many other splices as possible made in the factory.

3.08 REMOVAL OF FORMS, FALSEWORK AND CENTERING:

A. Maintain forms, falsework and centering in place until the concrete has attained minimum percentage of specified design strength in accordance with Schedule 1:

Structural Member	Minimum Percentage of Specified Design Strength	
	Schedule 1	Schedule 2
Footings; inverts; sides of beams; slabs and girders; slabs and beams on grade	25	20
Free-standing walls, columns and piers	40	30
Cantilevers	90	70

B. Early removal of forms, falsework and centering will not be allowed for concrete strength values below Schedule 2, but will be allowed for concrete strength values between Schedule 1 and Schedule 2 only after:

1. The Engineer has approved calculations showing anticipated concrete strengths at time of proposed early removal based on:

   a. Ratio of dead load over live load.
   b. Span, height and shape.
   c. Ratio of rise over span.
   d. Reshoring.
   e. Loads, resultant stresses and deformations to which concrete and reinforcing steel will be subjected at time of removal, subsequent to removal and until concrete has attained design strength.
   f. Prevailing site conditions.

2. Concrete strength attained prior to form removal has been determined by analysis of quality-assurance data in accordance with Section 03300.

C. Do not remove wood board forms within 48 hours of pouring concrete.

D. Do not alter loading conditions on concrete subsequent to removal of forms if it results in exceeding permissible stresses and deformations at attained concrete strengths.

E. The Engineer may permit early removal of concrete support without submittal of calculations prior to attainment of specified design strength if he considers such submittals to be unnecessary.

END OF SECTION

SECTION 03200

CONCRETE REINFORCEMENT

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies reinforcement for concrete structures and other facilities.

B. Related Work Specified Elsewhere:

1. Concrete formwork: Section 03100.
2. Cast-in-place structural concrete: Section 03300.

C. Definitions:

1. Cover: Thickness of concrete between outside surface of reinforcement and outside face of concrete.

1.02 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. Detail reinforcing in accordance with ACI SP-66.
b. Bar lists showing the individual weight of each bar, total weight of each bar size and total weight of bars on list. Base calculated weights on theoretical unit weights shown in ASTM A615, Table 1.
c. Details showing bonding of reinforcement for stray current and cathodic protection.

2. Certification:

a. Manufacturer's certificates.
b. Mill tests on each heat showing chemical and physical analyses performed in accordance with ASTM A615, as modified by ACI 318.
c. Record of mill tests traceable to individual reinforcement bars supplied to the project.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of the jurisdictional authorities.
2. ACI: SP-66, 318.
3. CRSI: Manual of Standard Practice; Placing Reinforcing Bars.
4. AASHTO: Standard Specifications for Highway Bridges.
5. ASTM: A82, A185, A615, A775, A706.

B. Allowable Tolerances:

1. Cut and bend reinforcing steel to conform to dimensions shown within the following tolerances:

a. Sheared length: Plus-or-minus one inch.
b. Depth of truss bars: Plus zero or minus 1/2 inch.
c. Stirrups, ties and spirals: Plus-or-minus 1/2 inch.
d. All other bends: Plus-or-minus one inch.

PART 2 – PRODUCTS

2.01 MATERIALS:

A. Reinforcing Steel Bars:

1. ASTM A615, Grade 60, modified in accordance with ACI 318.
2. ASTM A706, for all welding reinforcing bars, except for electrical bonding.
3. Epoxy Coating: ASTM A775, as shown. Epoxy Coating: ASTM A775, as shown.

B. Spiral Reinforcement: ASTM A82 or ASTM A615, Grade 60.

C. Welded Steel-Wire Fabric: ASTM A185.

D. Metal Accessories: As recommended by CRSI Manual of Standard Practice. Where concrete surfaces will be exposed to public view in finish structure, use supports with plastic-protected legs or stainless steel legs.

PART 3 – EXECUTION

3.01 CUTTING AND BENDING:

A. Perform cutting and bending in the shop. Bend steel cold. Do not bend or straighten bars so as to damage material.

B. Do not bend bars in the field except to correct minor errors and damage occurring during shipping and handling.

3.02 BAR SUPPORTS AND SPACERS:

A. Support bars by means of bolsters or chairs with no less than minimum required by ACI SP-66.

B. Reinforcing steel in bottom of slabs resting on earth may be supported by concrete brick or mortar blocks.

C. In walls, columns, piers and abutments hold reinforcing steel in position by means of mortar blocks, bar supports or spacers wired to reinforcing steel.

D. Do not use stones, clay bricks, wood blocks or pieces of broken concrete to support reinforcing steel.

E. Do not place bars or fabricated mats on layers of fresh concrete as work progresses.

3.03 PLACING AND FASTENING:

A. Arrange and place reinforcing steel as shown.

B. Secure reinforcement positively against displacement during placing of concrete.

C. Wire or clip bars together as recommended in CRSI Placing Reinforcing Bars.

D. Maintain reinforcing steel accurately in locations shown in tops of inverts to permit arrangements of anchor bolts for rail-tie plates.

E. Before placement, ensure that reinforcement is free from dirt, mill scale, rust scale, oil, grease and other foreign matter.

3.04 **SPLICING:**

A. Furnish reinforcing bars in full lengths as shown on the Contract Drawings and approved shop drawings.

B. Do not splice bars unless approved in writing.

C. Make splices when authorized, in accordance with ACI 318, except make all butt splices by welding with a capacity of not less than 125 percent of minimum yield strength of bar. Mechanical connections for tensile splice shall be by cadweld only. Connections for t Cadweld only. However, mechanical connection for precast prestressed structures and parking garages, when the splice is located inside the precast member, may be made by NMB Splices instead of the Cadweld, with prior approval of the Authority.

3.05 **ELECTRICAL BONDING:**

A. Weld steel straps to transverse end reinforcing bars and longitudinal reinforcing bars adjacent to joints between pour sections at locations shown.

B. No electrical bonding is required for epoxy coated rebar.

C. Thermite weld or cadweld stranded, bare-copper conductors to adjacent steel strips at specified end locations. Likewise, weld copper conductors to lapped, welded-wire fabric at joints in slabs at locations shown.

D. Additional copper bonding work adjacent to traction power substations: Section 16060.

3.06 **INSPECTION:**

A. Placement of concrete prior to approval of reinforcement and electrical bonding work is prohibited.

3.07 **CONCRETE PROTECTION FOR REINFORECMENT (COVER):**

A. Structures:

1. Concrete cast against and permanently exposed to earth – 3 inches.
2. Concrete exposed to earth or weather – 2 inches.
3. Concrete not exposed to weather or in contact with ground - 1½ inches.

3.08 **EPOXY COATING:**

A. Preparation of surface: Perform the following in order given:

1. Clean surface contaminated with oil and grease using naptha or xylol.
2. Remove weld slag, rust and mill scale from surfaces by wire brushing.
3. Coat surfaces immediately with methyl-methacrylate primer.
4. Apply coating only to surfaces which are dry and free of contaminants.

END OF SECTION

SECTION 03300

CAST-IN-PLACE STRUCTURAL CONCRETE

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies providing portland-cement cast-in-place concrete.

B. Related Work Specified Elsewhere:

1. Concrete formwork: Section 03100.
2. Concrete reinforcement: Section 03200.
3. Copper bonding work: Section 16060.

1.02 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. Testing Laboratory:

1. Furnish the services of an independent testing laboratory. Employment of an independent laboratory does not relieve the Contractor of the obligation to perform the work in accordance with requirements of the Specifications and Drawings. Submit certified results of the tests performed.
2. Furnish proof that the laboratory satisfies the requirements of the American Council of Independent Laboratories' Recommended Requirements for Independent Laboratory Qualification. Laboratory need not be a member of the American Council of Independent Laboratories.
3. Certify that testing equipment has been calibrated by an accredited calibration agency at not more than 12-month intervals using devices of accuracy traceable to the National Institute of Standards and Technology (NIST) or accepted values of material physical constants

C. 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:
2) Working-stress method: 20 percent.
3) Ultimate-strength method: 10 percent.
4) Prestressed structures: 10 percent.
5) Average of the following numbers of consecutive strength tests to be equal to or greater than specified strength:

a) Working-stress method: Six.

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

5. Appearance:

a. Cured concrete exposed to public view shall be uniform in color, texture and finish with no discernible form or patch marks, grain imprint, joint irregularities or discoloration. Use only manufacturer approved chemically reactive release agents on HDO plywood forms.
b. Final selection and approval for color shall be made by the Engineer.

D. 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.

E. Ready-Mixed Concrete: ASTM C94.

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

a. Samples:

1) Concrete surface sealer: Two, each one pint.
2) Membrane-forming curing compound: Two of each type, each one pint.

2. Sandblast finish:

a. Number 6 sandblast finish as specified, each 12 inches square by two inches: Two.
b. Seal 1/2 of face of each sample with concrete surface sealer.
c. If samples are not approved or if concrete mix is changed, submit additional samples until approved.
d. When samples have been approved, submit details of procedures followed to produce approved surface finish including, but not limited to, the following:

1) Size and type of nozzle.
2) Air pressure.
3) Distance of nozzle from surface blasted.
4) Duration of blast.

3. Certification:

a. Ingredients:

1) 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.
2) 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.
c. Batch tickets:

1) Before unloading at the site, submit certification or delivery ticket from concrete supplier with each batch delivered to the site bearing the following information:

a) Name of supplier.
b) Name of batching plant and location.
c) Serial number of ticket.
d) Date.

e) Truck number.
f) Specific job designation: Contract number and location.
g) Volume of concrete in cubic yards.
h) Class and type of concrete.
i) Time loaded.
j) Type and brand of cement.
k) Weight of cement and fly ash or ground-iron blast-furnace slag.
l) Maximum size of aggregates.
m) Weights of coarse and fine aggregates.
n) Maximum amount of water to be added and amount of water added at the site.
o) Kind and amount of admixtures.

4. Documentation:

a. Proposed methods for controlling concrete temperature and plans for placing concrete taking into account sun, heat, wind, ambient air temperature or other limitations of facilities that will prevent proper finishing or curing.
b. Quality control plan for floor treatment. Submit as specified prior to installation.
c. Quality control reports. Submit as specified after installation.
d. Design mixes:

1) Prior to placing concrete, submit design mixes for each class and type of concrete, certifying that proposed concrete ingredients and proportions will result in concrete mix meeting specified requirements.
2) Include for each class and type of concrete as many mix designs as there are combinations of different ingredients or types of ingredients anticipated to cover requirements of the work.
3) Establish mix designs through an approved design laboratory.
4) Design concrete mix for protection against alkali-aggregate reactivity.
5) The Contractor may present for approval a concrete mix previously approved for Authority work provided such mix is made with proposed ingredients that meet requirements and provided that concrete has complied with compressive-strength requirements based on control record of at least 30 consecutive-strength tests recently obtained.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Aggregates:

1. Transport and stock pile aggregate separately according to sources and gradations. Handle so as to prevent segregation, loss of fines and contamination by earth or other foreign materials.
2. If aggregates show segregation or if different grades become mixed, rescreen before placing in proportioning bins.
3. Do not combine aggregate from different sources or of different gradations except to obtain different gradations.
4. Do not transfer aggregates directly from trucks, railroads cars or barges to proportioning bins when moisture content is such that it will affect accurate proportioning of concrete mixture. In such cases, stockpile aggregate until excess moisture drains off.

B. Packaged Cement:

1. Deliver to project site in original sealed packages labeled with weight, name of manufacturer, brand and type.
2. Store packages in watertight building.
3. Do not use cement which has been reclaimed by cleaning bags.
4. Do not use cement which has been exposed to moisture or contaminated.
5. Deliver packages conforming to weight specified.
6. Packaged cement will be subject to testing.

C. Bulk Cement:

1. Store bulk cement separately from other cement and protect to prevent exposure to moisture and contamination.
2. In ready-mix plant, provide facilities to maintain separation of cement meeting specified requirements from other cement.
3. Provide in cement manufacturer's plant, facilities for sampling cement at weighing hopper or in feed line immediately before entering hopper.

D. Ready-Mixed Concrete: ASTM C94.

E. Blast-Furnace Slag or Fly Ash for use with Portland Cement:

1. Transport in covered carriers.
2. Store in watertight bins or silos to provide protection from dampness and contamination. When compartmented bins are used, conduct periodic, but not less than weekly checks between adjacent bins to avoid contamination of either of the stored materials.

F. Concrete Additives, Sealers and Corrosion Inhibitor. As required by the manufacturer.

1.05 WARRANTY

A. Penetrating Concrete Sealer: Provide a minimum effective service life warranty of 10 years for the penetrating concrete sealer.

PART 2 – PRODUCTS

2.01 MATERIALS:

A. Cementitious Materials:

1. Portland Cement: ASTM C150, Types I and II. Use Type II only for underground structures.

a. Alkali content not to exceed 0.6 percent.

2. Blended Hydraulic Cement: ASTM C595 Type IS and IP.

B. Ground-Iron Blast Furnace Slag: ASTM C989, Grade 100 or 120.

C. Fly Ash: ASTM C311 and ASTM C618, Class F:

1. Loss on ignition not to exceed 4 percent.
2. Maximum available alkalis (for combination of cement and fly ash) not to exceed 0.6 percent based on proportions to be used and alkalinity measurements for cement and fly ash individually or in combination.

a. Fly ash used to be qualified for each source.

3. Uniform color when used in concrete exposed to public view.

D. Aggregates:

1. Aggregates for normal concrete and shotcrete: ASTM C33 with the following additional requirements:

a. Coarse aggregate: Gravel, crushed gravel or crushed stone.

1) Deleterious substances:

a) Maximum allowable amounts:

Substance	Maximum Allowable Percentage by Weight
(1) Soft particles:	5.0
(2) Coal and lignite particles:	0.5
(3) Friable particles:	0.25
(4) Material passing Size 200 sieve:	1.0
(5) Thin or elongated pieces:	15.0
(6) Other local deleterious substances	1.0

b) Soft particles: Higher percentage may be approved where concrete is not subject to abrasion, provided concrete strength is achieved without the use of excess cement.
c) Crushed aggregates: If material finer than Number 200 sieve consists of dust of fracture essentially free from clay or shale, percentage may be increased to 1.5.
d) Thin or elongated pieces: Length of pieces to be greater than five times the smallest dimensions of a circumscribing rectangular prism.

2) Percentage of wear: 45 maximum when tested in accordance with ASTM C131 and ASTM C535.
3) Weighted percentage of loss: 15-percent maximum by weight when subjected to five cycles of magnesium sulfate soundness test in accordance with ASTM C88.
4) Gradation: In accordance with ASTM C33, Table 2, and represented by a smooth gradation curve within required limits.

b. Fine aggregate:

1) Washed natural sand or washed stone sand. Stone sand may be subject to special gradation requirements as directed.

2) Gradation in accordance with ASTM C33.

a) Minimum percentages of material passing Size 50 and Size 100 sieves may be reduced to five and zero, respectively, if aggregate is to be used in concrete with three percent minimum air entrainment, or in concrete containing more than 517 pounds of cement per cubic yard.

3) Weighted percentage of loss not more than 12 percent by weight when subjected to five cycles of magnesium sulfate soundness test in accordance with ASTM C88.

4) Deleterious Substances:

Substance	Maximum Allowable Percentage by Weight
a) Friable particles:	1.0
b) Coal and lignite:	0.5
c) Material passing the Size 200 sieve	5.0
d) other deleterious substances, such as shale, alkali, mica, coated grains, soft and flaky particles	2.0

5) Free from injurious amounts of inorganic impurities as determined by ASTM C40. Should materials fail to pass test for organic impurities in sand for concrete, retest in accordance with ASTM C87. If fine aggregate shows by colorimetric test a darker color than that of sample originally approved for the work, stop using such aggregate until approved tests have been made to determine whether change in color is indicative of injurious amount of deleterious substances.

c. Evaluate for potential alkali aggregate reactivity:

1) Perform a petrographic examination in accordance with ASTM C295. The petrographic analysis will identify the constituents of the fine and coarse aggregate and will also identify aggregate found to be potentially alkali-carbonate reactive. Fine and coarse aggregate containing more than the following quantities of constituents is unacceptable:

a) Optically strained, microfractured or microcrystalline quartz exceeding five percent (a common constituent or granite and granite gneiss).
b) Chert, Metaquartzite, Chalcedony or combination thereof exceeding three percent. However, fine aggregate may contain up to eight percent provided that mortar bar test results are acceptable.
c) Tridymite or cristobalite exceeding one percent.
d) Opal exceeding five percent.
e) Natural volcanic glass in volcanic rocks exceeding three percent.

2) Test aggregate for alkali-silica reactivity in accordance with ASTM C1260. Aggregate sources that exhibit a C1260 mean mortar bar expansion at 16 days greater than 0.08 percent are unacceptable.

3) Aggregate identified by the petrographic analysis to be potentially alkali-carbonate reactive is to be further evaluated in accordance with ASTM C586. Expansion of test specimen cylinders not to exceed 0.10 percent after 28 day immersion in NaOH solution.

d. Aggregate which fails the evaluation criteria for potential alkali aggregate reactivity may be reclassified as acceptable if prior field performance demonstrates that the aggregate is nonreactive. Include service records (material records, batch quantities, exposure conditions, and petrographic evaluation) demonstrating the aggregate to be nonreactive in the mix design submittal.

E. Water

1. Natural potable water with no pronounced taste or odor.
2. Containing no impurities, suspended particles, algae or dissolved natural salts in quantities that will cause:

   a. Corrosion of reinforcing steel.
   b. Volume change that will increase shrinkage cracking.
   c. Efflorescence.
   d. Excessive air entraining.

3. pH: Not less than five.
4. When tested in accordance with AASHTO T26, standard mortar-briquette tests to show no indication of unsoundness, no change in setting time in excess of plus-or- minus 30 minutes and no reduction in strength in excess of 10 percent.

F. Ready-Mixed Concrete: ASTM C94, Option C.

G. Admixtures:

1. In accordance with the following:

   a. Air-entraining admixtures: ASTM C260.
   b. Chemical admixtures: ASTM C494.

2. Approved brands: Chlorides may be present in admixtures provided total chloride in mixing water of proposed concrete mixture, including chloride ions contributed by admixture or admixtures, aggregate and mixing water is not in excess of 150 ppm.
3. Meeting requirements of reference standards or documented to have five-year minimum history of demonstrably satisfactory performance for similar structures under equivalent conditions.

H. Aluminum Powder: FS A-A-341A, free of oil, grease, soluble alkalis and organic materials, gradation as approved.

I. Ferrous Aggregate:

1. Cast-iron particles, ASTM A43, ASTM A47, or ASTM A48, free of oil, grease, soluble alkalis and organic materials.
2. Aggregate graded as follows:

Sieve Designation US	Percentage by Weight

US Standard Square Mesh	Passing Individual Sieves
3/8 inch	----
Size 4	100
Size 8	90 – 100
Size 16	75 – 90
Size 30	45 – 60
Size 50	15 – 25
Size 100	10 – 20

3. If recommended by manufacturer and approved, in lieu of the above gradation use lower percentage of aggregate passing Size 100 sieve.

J. Abrasive Aggregate: 60 to 75 percent silicon-carbide abrasive, bonded by vitreous ceramic material, black, graded from 12 to 30.

K. Floor Treatment:

1. Sealer: Zinc or magnesium fluosilicate and wetting agent formulated and mixed with water in concentration recommended by manufacturer.
2. Floor hardener system:

a. Floor hardener:

1) Free from non-ferrous metallic particles, filler material, silica sand, natural aggregates, rust and materials which disguise rust.
2) Ready-to-use formulation proportioned, mixed and packaged at factory ready for application.
3) Ingredients proportioned to maintain two parts well-graded iron aggregate to one part consisting of cement, plasticizing agents and other ingredients designed to absorb moisture from floor slab.
4) Color: Per sample, or as selected by the Engineer.
5) Masterplate 200, Master Builders, or equal.

b. Floor curing compound:

1) Clear modified-acrylic resin.
2) Moisture retention: In accordance with ASTM C309 when applied at a rate of 400 square feet per gallon.
3) Masterkure, Master Builders, or equal.

L. 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.

M. 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.

N. 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:

Individual Sieve Size	Percent by Weight Retained on Sieve
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)

O. Waterstop: Section 03100.

P. Chairs for Reinforcement: Plastic or stainless steel.

Q. Corrosion-inhibitor in concrete. The corrosion-inhibitor shall be calcium nitrite-based admixture DCI or approved equal. Use four (4) gallons per cubic yard of the corrosion inhibitor when the water-cement ratio is 0.40 or less and use three and a half gallons (3-1/2) per cubic yard when water-cement ratio is 0.38 or less.

2.02 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 C1107.

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

3.01 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 specified. Unless otherwise indicated, use Class 4000.
3. Each class of concrete may comprise one or more mixes 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. Maximum allowable ground-iron blast-furnace slag: 50 percent of the total weight of the portland cement and ground-iron blast-furnace slag mixture.
c. Maximum allowable fly ash: 20-percent of the total weight of the portland cement and fly-ash mixture.

4. Concrete with fly ash or ground-iron blast-furnace slag may be used at locations shown on the drawings.

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

* one bag of cement = 94lbs. of cement

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.

E. Testing of Concrete:

1. General:

a. Provide the Engineer with molds and concrete, and cast specimens for testing. In addition, furnish necessary testing equipment and tools to perform sampling, slump tests and yield tests. Furnish boxes for shipping samples.

2. Perform strength tests by making not less than one set of standard cylindrical test specimens for each 100 cubic yards of concrete or any portion thereof for each structure.

a. For each work shift, when concrete is delivered, make at least one set of specimens. A set of test specimens consists of at least three standard cylinders from a batch.
b. Perform slump tests, unit weight and air content tests with no less frequency than that of strength-specimen sets.

3. Concrete strengths:

a. Determine strengths from standard test specimens according to ASTM C31 and ASTM C172 and cured and tested in accordance with ASTM C39 by the testing laboratory.

Core drilling and testing in accordance with ASTM C42. Consider the effects of corrosion-inhibiting admixture and other admixtures on the strength of the concrete, in the concrete mix design. The corrosion-inhibiting admixture and other admixtures must be present in the concrete used for the test of the proposed mix strength.

b. Compute and evaluate in accordance with ASTM C94.

F. Variability of Constituents in Concrete:

1. Take representative samples of concrete mortar.
2. Maximum allowable unit-weight variation of air-free mortar taken from consecutive batches as discharged from mixer:

   a. Average of two mortar weights: 0.8-percent maximum.
   b. Average of six mortar weights: 0.5-percent maximum.

3. Maximum allowable weight variation of coarse aggregate per cubic foot of concrete taken from consecutive batches as discharged from mixer.

   a. Average of two weights: Five-percent maximum.

G. Allowable Concrete Finish Tolerances:

1. Finish concrete elements to dimensions, elevations and positions shown within the tolerances specified for each:

   a. Formed surfaces such as walls, roof soffits, columns, beams and girders: Plus-or-minus 1/4 inch.

3.02 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. Adequacy of mixing will be determined by the Engineer by means of mixer performance tests in accordance with USBR Concrete Manual, Designation 26, Variability of Constituents in Concrete, in the appendix.
   d. The Engineer may reduce size of batch to be mixed or increase mixing time when charging and mixing operations fail to produce concrete which conforms to specified requirements and which has uniform coloration and consistency.
   e. Add water prior to, during and following mixer-charging operations. Do not overmix or add water to maintain consistency.
   f. Use of concrete to which water in excess of amount permitted by approved design mix has been added to overcome conditions caused by excessive retention in mixer is prohibited.

2. Central-mixed concrete:

   a. Arrange mixers in centralized mixing plant so that mixing action in mixers can be conveniently observed by the Engineer and plant operator.

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

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

3. Truck-mixed concrete: Use equipment and procedures that conform to the requirements of ASTM C94 and ACI 304, Chapter 5, with the following additional requirements:

a. Introduce materials, including water and mixtures, into the mixing drum only at the central batching plant, or
b. Transport aggregates from the central plant to the jobsite in the mixing drum and add measured and recorded cement, admixtures and water into the drum prior to mixing at discharge point.
c. When ice is used, add it with the water and counted as part of the water- cement ratio.
d. Place concrete within 90 minutes after cement is introduced into the mixing drum.
e. Accomplish initial mixing by 70 to 100 revolutions with drum rotating at the manufacturer's recommended speed. 30 revolutions at mixing speed will be required, if the addition of water is permitted. Do not exceed total of 300 mixing and agitating revolutions.

4. 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 1/2 inch or more.

3.03 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.
3. Design long conveyor runs to discharge concrete into hopper, without segregation, before it is deposited in forms.
4. Ensure that pumps, pneumatic equipment, pipes, chutes and troughs are cleaned of dirt and concrete before use.

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.

3.04 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.

3.05 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.

D. 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.

E. 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.

3.06 COLD WEATHER CONCRETING:

A. Do not place concrete when ambient temperature is less than 55F and falling. Do not place concrete unless the form temperature at the time of placement is at least 40F.

B. When ambient temperature is 40F 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 55F 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 20F 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 55F 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.

3.07 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.

3.08 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 Engineer.

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. Install forms for vertical joints. Remove forms as soon as concrete has attained sufficient strength to be self-supporting.

3.09 CONCRETE FINISHING:

A. When forms are removed, do not remedy voids, stone pockets and other defects until the Engineer has inspected them and given directions.

B. Finish concrete surfaces as shown and as follows:

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. 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. 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. 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.

C. Do not sprinkle water or cement on surfaces to be trowel finished.

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 Engineer 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 borne 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.

3.13 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 Engineer.

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.

3.14 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.

END OF SECTION

SECTION 05500

MISCELLANEOUS METAL

PART 1 – GENERAL

1.01 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. Concrete, concrete fill and non-shrink grout: Section 03300.
2. Field painting: Section 09920.
3. Concrete formwork: Section 03100.
4. Concrete reinforcement: Section 03200.

1.02 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.

1.03 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.

1.04 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.

1.05 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

2.01 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.

2.02 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. Steel Pipe: ASTM A 53, standard weight (Schedule 40), unless another weight is indicated or required by structural loads.

E. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A666, Type 304. Type 316L for corrosive environments.

F. Stainless-Steel Bars and Shapes: ASTM A276, Type 304. Type 316L for corrosive environments.

G. Hot-rolled carbon steel sheets and strips: ASTM A570.

H. Pipe, Pipe Sleeves and Pipe Fittings:

1. Cast iron: ASTM A74, service weight.
2. Steel: ASTM A53, galvanized unless otherwise shown or specified.

I. Guard Chain: ASTM A413, Class Grade 28, galvanized steel, 9/32-inch thick, complete with stainless-steel eyes, spring-loaded catches and mounting components.

2.03 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.

2.04 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, zinc-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.

2.05 CONCRETE AND GROUT:

A. Nonshrink Grout: Section 03300.

B. Concrete Fill: Normal weight, minimum 3,000 psi structural concrete as required in Section 03300, 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 moisture and cleaning materials.
2. Surface hardener: Water-soluble, inorganic fluosilicate compound for curing, hardening and dustproofing fresh concrete.

2.06 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.

2.07 LADDERS:

A. General: Fabricate ladders for locations as called out on drawings or as required, 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, 1/2-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:

2.08 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.

2.09 SAFETY TREAD:

A. FS RR-T-650, Type C, metallic, nonskid, class and style as shown.

B. Drilled and countersunk to receive flathead screws.

2.10 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.

2.11 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. Lifting Eye: ASTM A572, Grade 50, one-inch diameter steel rod, welded, galvanized after fabrication.

2.12 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

3.01 PREPARATION:

A. Remove foreign substances from surfaces to receive metal items.

B. Protect surrounding surfaces from damage while performing the work of this section.

3.02 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.

3.03 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 07841

FIRESTOPPING

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This Section perimeter fire containment systems and specifies through penetration firestop systems for penetrations through the following fire resistance rated assemblies:

1. Floors.
2. Roofs.
3. Walls and partitions.
4. Construction enclosing compartmentalized areas.
5. Smoke barriers

B. Related Work Specified Elsewhere:

1. Division 15 Sections specifying piping penetrations.
2. Division 16 Sections specifying cable and conduit penetrations.

1.02 PERFORMANCE REQUIREMENTS:

A. General: For the following constructions, provide through penetration firestop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire resistance rating of assembly penetrated.

1. Fire resistance rated non-load bearing walls, including partitions, with fire protection rated openings.
2. Fire resistance rated floor assemblies
3. Fire resistance rated roof assemblies.

B. F-Rated Systems: Provide through penetration firestop systems with F ratings indicated, as determined per ASTM E 814, but not less than that equaling or exceeding fire resistance rating of constructions penetrated.

C. LHJ T Rated Systems: For the following conditions, provide through penetration firestop systems with T ratings indicated, as well as F ratings, as determined per ASTM E 814, where systems protect penetrating items exposed to potential contact with adjacent materials in occupiable floor areas:

1. Penetrations located outside wall cavities.
2. Penetrations located outside fire resistive shaft enclosures.
3. Penetrations located in construction containing fire protection rated openings.
4. Penetrating items larger than 4 inch diameter nominal pipe or 16 sq. in. in overall cross sectional area.

D. For through penetration firestop systems exposed to view, traffic, moisture, and physical damage, provide products that after curing do not deteriorate when exposed to these conditions both during and after construction.

1. For piping penetrations for plumbing provide moisture resistant through penetration firestop systems.
2. For floor penetrations with annular spaces exceeding 4 inches in width and exposed to possible loading and traffic, provide firestop systems capable of supporting floor loads involved either by installing floor plates or by other means.
3. For penetrations involving insulated piping, provide through penetration firestop systems not requiring removal of insulation.

E. For through penetration firestop systems exposed to view, provide products with flame spread ratings of less than 25 and smoke developed ratings of less than 450, as determined per ASTM E 84.

1.03 SUBMITTALS:

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

B. Product Data: For each type of through penetration firestop system product indicated.

C. Shop Drawings: For each through penetration firestop system, show each kind of construction condition penetrated, relationships to adjoining construction, and kind of penetrating item. Include firestop design designation of testing and inspecting agency acceptable to authorities having jurisdiction that evidences compliance with requirements for each condition indicated.

1. Submit documentation, including illustrations, from a qualified testing and inspecting agency that is applicable to each through penetration firestop system configuration for construction and penetrating items.

D. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

E. Certification: Signed by manufacturers of through penetration firestop system products certifying that products furnished comply with requirements.

1.04 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of the jurisdictional authorities.
2. ASTM E 84, E 814.
3. UL - 1479.

B. Installer Qualifications: An experienced installer who has completed through penetration firestop systems similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in service performance.

C. Source Limitations: Obtain through penetration firestop systems, for each kind of penetration and construction condition indicated, from a single manufacturer.

D. Fire Test Response Characteristics: Provide through penetration firestop systems that comply with the following requirements and those specified in "Performance Requirements" Article:

1. Through penetration firestop systems are identical to those tested per ASTM E 814. Provide rated systems complying with the following requirements:

    a. Through penetration firestop system products bear classification marking of qualified testing and inspecting agency.
    b. Through penetration firestop systems correspond to UL in Fire Resistance Directory reference to through penetration firestop system designations.

1.05 DELIVERY, STORAGE, AND HANDLING:

A. Deliver through penetration firestop system products to Project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product and manufacturer; date of manufacture; lot number; shelf life, if applicable; qualified testing and inspecting agency's classification marking applicable to Project; curing time; and mixing instructions for multicomponent materials.

B. Store and handle materials for through penetration firestop systems to prevent their deterioration or damage due to moisture, temperature changes, contaminants, or other causes.

1.06 **PROJECT CONDITIONS:**

A. Environmental Limitations: Do not install through penetration firestop systems when ambient or substrate temperatures are outside limits permitted by through penetration firestop system manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.

B. Ventilate through penetration firestop systems per manufacturer's written instructions by natural means or, where this is inadequate, forced air circulation.

1.07 COORDINATION:

A. Coordinate construction of openings and penetrating items to ensure that through penetration firestop systems are installed according to specified requirements.

B. Coordinate sizing of sleeves, openings, core drilled holes, or cut openings to accommodate through penetration firestop systems.

C. Do not cover up through penetration firestop system installations that will become concealed behind other construction until the Engineer has examined each installation.

PART 2 – PRODUCTS

2.01 FIRESTOPPING, GENERAL:

A. Compatibility: Provide through penetration firestop systems that are compatible with one another, with the substrates forming openings, and with the items, if any, penetrating through penetration firestop systems, under conditions of service and application, as demonstrated by through penetration firestop system manufacturer based on testing and field experience.

B. Accessories: Provide components for each through penetration firestop system that are needed to install fill materials and to comply with "Performance Requirements" Article. Use only components specified by through penetration firestop system manufacturer and approved by the qualified testing and inspecting agency for firestop systems indicated. Accessories include, but are not limited to, the following items:

1. Permanent forming/damming/backing materials, including the following:

    a. Slag /rock wool fiber insulation.
    b. Sealants used in combination with other forming/damming/backing materials to prevent leakage of fill materials in liquid state.
    c. Fire rated form board.
    d. Fillers for sealants.

2. Temporary forming materials.
3. Substrate primers.
4. Collars.
5. Steel sleeves.

2.02 FILL MATERIALS:

A. General: Provide through penetration firestop systems containing the types of fill materials indicated in the Through Penetration Firestop System Schedule at the end of Part 3 by reference to the types of materials described in this Article. Fill materials are those referred to in directories of the referenced testing and inspecting agencies as fill, void, or cavity materials.

B. Latex Sealants: Single component latex formulations that after cure do not re-emulsify during exposure to moisture

C. Firestop Devices: Factory assembled collars formed from galvanized steel and lined with intumescent material sized to fit specific diameter of penetrant.

D. Intumescent Composite Sheets: Rigid panels consisting of aluminum foil faced elastomeric sheet bonded to galvanized steel sheet.

E. Intumescent Putties: Non-hardening dielectric, water resistant putties containing no solvents, inorganic fibers, or silicone compounds.

F. Intumescent Wrap Strips: Single component intumescent elastomeric sheets with aluminum foil on one side.

G. Mortars: Prepackaged, dry mixes consisting of a blend of inorganic binders, hydraulic cement, fillers, and lightweight aggregate formulated for mixing with water at Project site to form a non-shrinking, homogeneous mortar.

H. Pillows/Bags: Reusable, heat expanding pillows/bags consisting of glass fiber cloth cases filled with a combination of mineral fiber, water insoluble expansion agents and fire retardant additives.

I. Silicone Foams: Multicomponent, silicone based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.

J. Silicone Sealants: Moisture curing, single component, silicone based, neutral curing elastomeric sealants of grade indicated below:

    1. Grade for Horizontal Surfaces: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces.
    2. Grade for Vertical Surfaces: Nonsag formulation for openings in vertical and other surfaces.

2.03 FILL MATERIALS:

A. Where indicated for gaps between the perimeter edge of fire-resistance-rated floor assemblies and non-fire-resistance-rated exterior curtain walls, provide a perimeter fire-containment system with the fire-test response characteristics indicated, as determined by testing identical systems per UBC Standard 26-9 and UL 2079 by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Materials shall be identified with appropriate markings of applicable testing and inspecting agency.

PART 3 – EXECUTION

3.01 EXAMINATION:

A. Examine substrates and conditions, with Installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION:

A. Surface Cleaning: Clean out openings immediately before installing through penetration firestop systems to comply with written recommendations of firestop system manufacturer and the following requirements:

1. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of through penetration firestop systems.
2. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with through penetration firestop systems. Remove loose particles remaining from cleaning operation.
3. Remove laitance and form release agents from concrete.

B. Priming: Prime substrates where recommended in writing by through penetration firestop system manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

C. Masking Tape: Use masking tape to prevent through penetration firestop systems from contacting adjoining surfaces that will remain exposed on completion of Work and that would otherwise be permanently stained or damaged by such contact or by cleaning methods used to remove smears from firestop system materials. Remove tape as soon as possible without disturbing firestop system's seal with substrates.

3.03 THROUGH-PENETRATION FIRESTOP SYSTEM INSTALLATION:

A. General: Install through penetration firestop systems to comply with "Performance Requirements" Article and firestop system manufacturer's written installation instructions and published drawings for products and applications indicated.

B. Install forming/damming/backing materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross sectional shapes and depths required to achieve fire ratings indicated.

C. Install fill materials for firestop systems by proven techniques to produce the following results:

1. Fill voids and cavities formed by openings, forming materials, accessories, and penetrating items as required to achieve fire resistance ratings indicated.
2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
3. For fill materials that will remain exposed after completing Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.04 FIELD QUALITY CONTROL:

A. Where deficiencies are found, repair or replace through penetration firestop systems so they comply with requirements.

3.05 **IDENTIFICATION:**

A. In areas not exposed to public view, identify through penetration firestop systems with pressure sensitive, self-adhesive, preprinted vinyl labels. Attach labels permanently to surfaces of penetrated construction on both sides of each firestop system installation where labels will be visible to anyone seeking to remove penetrating items or firestop systems. Include the following information on labels:

1. The words: "Warning Through Penetration Firestop System Do Not Disturb."

3.06 CLEANING AND PROTECTION:

A. Clean off excess fill materials adjacent to openings as Work progresses by methods and with cleaning materials that are approved in writing by through penetration firestop system manufacturers and that do not damage materials in which openings occur.

B. Provide final protection and maintain conditions during and after installation that ensure through penetration firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated through penetration firestop systems immediately and install new materials to produce through penetration firestop systems complying with specified requirements.

3.07 THROUGH-PENETRATION FIRESTOP SYSTEM SCHEDULE:

A. Where UL classified systems are indicated, they refer to the alpha numeric designations listed in UL's "Fire Resistance Directory" under product Category XHEZ.

B. Firestop Systems for Metallic and Non-metallic Conduit, Tubing, Sleeves, Cable Trays and Cables:

1. UL 1479: Fire rated for 3 hours.
2. Type of fill materials: One or more of the following:

a. Silicone sealant.
b. Intumescent putty.
c. Silicone foam.

C. Firestop Systems for Insulated Pipes: Comply with the following:

1. UL 1479: CAJ 5087.
2. Type of Fill Materials: Intumescent putty.

D. Firestop Systems for Miscellaneous Mechanical Penetrations: Comply with the following:

1. UL 1479: CAS 8033.
2. Type of Fill Materials: Mortar.

E. Firestop Systems for Ductwork: Comply with the following:

1. UL 1479: WJ7007.
2. Type of Fill Materials: Intumescent sealant.

END OF SECTION

SECTION 09920

FIELD PAINTING

PART 1 – GENERAL

1.01 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.
6. UL labels on fire-rated doors and frames.
7. Precast or pre-stressed 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.

1.02 SUBMITTALS:

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

1. Samples:

a. Three each of each color and texture, with identification of materials keyed to those specified and application methods.
b. Samples of paint scheduled for application to smooth finishes applied to 12-inch square hardboard or metal panels.
c. 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.

1.03 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.

1.04 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.

1.05 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

2.01 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.

2.02 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:

1. Ferrous metal: Silicone-alkyd, semigloss.
2. Zinc-coated metal: Silicone-alkyd, semigloss.
3. Mechanical and electrical items (not finish painted): See substrate materials above.

B. 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.

C. Ferrous Metal - Alkyd, Semigloss: Two coats over primer (primer is not required on shop-primed items):

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.

2.03 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 floors: Epoxy, gloss, with anti-slip aggregate.
2. Ferrous metal:

a. Exposed steel structure: Silicone-alkyd, semigloss.
b. Other interior ferrous metal: Alkyd, semigloss.

3. Zinc-coated metal: Alkyd, semigloss; except silicone-alkyd where part of ferrous metal assemblies painted with silicone-alkyd.
4. Non-ferrous metal: Alkyd, semigloss.
5. Mechanical and electrical items (not finish painted): See substrate materials above.

B. Concrete Floor Surfaces - Epoxy, Gloss: Two coats over primer, with anti-slip aggregate in finish coat: Chiller Plant Floors and equipment pads shall be painted with battle ship grey or equal, and the safety lines and tripping hazards shall be painted yellow or red.

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.

C. 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.

D. 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.

E. 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.

F. 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

PART 3 – EXECUTION

3.01 PREPARATORY WORK:

A. 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 benzene 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.

3.02 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.

3.03 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.

3.04 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.

3.05 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. Size of Stencil Letters for Piping Identification:

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

D. Schedule of Colors and Legends:

Line	Pipe Color	Black Stenciled Legend
Hot water lines	Yellow	HW, HWR
Potable cold water lines	Blue	CW
Chilled water lines	Blue with yellow band	CHWS, CHWR
Fire lines	Red	F (use White Stencil instead of black)
Condensate lines	White	C
Condenser water lines	White with blue band	CWS, CWR
Soil and waste lines	White	S
Vent lines	Grey with white band	V
Storm Water lines	White	ST-W
Air and control air lines	Green	A

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:

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. 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.

2. 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. Concrete equipment subbases (housekeeping pads):

a. Concrete: Sections 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.

B. Isolation-Unit Types and Deflection:

1. Fans and air-conditioning units: Floor-mounted and ceiling-suspended.

a. Spring isolators designed for a minimum of 1.5 inches deflection.
b. Snubbers:

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:

a. 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.

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:

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

1. Samples:

a. Labels and tags in each size.

2. Documentation:

a. Charts for valves; include valves identification number, location, and purpose.

PART 2 – PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. Nameplates: Laminated plastic.

B. Tags: 18-guage 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.

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 terminating 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 venture 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 flanges, and venturi tubes 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.

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 flame proofing and fireproofing treatments for the purpose of achieving specified fire-hazard ratings for insulation not meeting specified requirements is prohibited.

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.

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. 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/ Hot water/ Tempered water piping insulation:

a. Rigid premolded cellular glass: Covered with aluminum jacket 0.016-inch thick; ASTM C552.
b. Rigid premolded insulation sleeving: Thermal-pipe and tube covering, mineral fiber, industrial-type covered with aluminum jacket 0.016-inch thick; ASTM C552, all-service jacket.
c. Insulation for buried or embedded pipe: As specified or rigid polyurethane, one-inch thick, ASTM C552.

3. Exterior Condenser-water piping insulation:

a. Rigid premolded cellular glass: Covered with aluminum jacket 0.016-inch thick; ASTM C552.
b. Rigid premolded insulation sleeving: Thermal-pipe and tube covering, mineral fiber, industrial-type covered with aluminum jacket 0.016-inch thick; ASTM C552, all-service jacket.

B. Chilled-Water Pump Insulation:

1. Rigid premolded cellular glass: Two inches thick, ASTM C552.

C. Chiller Insulation:

1. Insulation:

a. 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.
c. Glass cloth: MS MIL-C-20079, Type 1, Class 2.

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.

D. Air-Separator Insulation:

1. As specified for chilled-water pump.

E. Compression-Tank Insulation:

1. As specified for chiller.

F. Expansion-Joint Insulation: Flexible unicellular, ASTM C534, one-inch thickness, two layers.

G. Wire Mesh: Galvanized wire, 22-gauge, one-inch mesh welded.

H. Corner Beads: Galvanized steel, 26-gauge, 2 1/2-inch wings.

I. Rigid-Insulation Adhesive and Sealer: Cold-applied, nonhardening asphaltic-type, in accordance with MS MIL-B-19564.

J. Vinyl-Emulsion Mastic: As recommended by manufacturer of rigid insulation.

K. 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.

L. 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.

M. 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. Unless otherwise shown, insulate the following:
8. Ancillary-area air-conditioning ductwork, supply and return, except ductwork within air-conditioned space.
9. Ancillary-area heating ductwork, ventilating ductwork, and combined heating and ventilation ductwork, supply and return ductwork within heated space.

B. Chilled-Water Pump Insulation:

1. Rigid premolded cellular glass: Two inches thick, ASTM C552.

C. Piping Insulation:

1. Chilled-water/Hot water/ Tempered 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) Rigid premolded insulation sleeving: Install one layer of two-inch thick on supply and return piping, valves, and fittings as follows:

a) IPS sizes: 1/2 inch through 30 inches.
b) Copper tubing: 1/2 inch through 6-1/8 inches.

2. 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 strap as specified.
f. Over elbows provide mitered insulation covered with aluminum jacket material.

D. 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, to that both ends project slightly beyond each end of saddle.
3. Cut ends of insulation flush with saddle ends.
4. Use of filter, adhesive or other material to fill voids or imperfections in insulation is prohibited.

E. 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.

F. 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.

G. 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.

H. 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 chilled-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:

   a. 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.
   b. Line metal covers with insulation of type and thickness used for cooler shell. Impale insulation on weld pins and secure with speed washers.
   c. Seal voids and joints with vapor-barrier mastic to prevent infiltration of moisture in space between insulation and metal cover.

I. Application of Air Separator Insulation:

1. As specified for chilled-water pump.

J. Application of Compression-Tank Insulation:

1. As specified for chiller.

END OF SECTION

SECTION 15120

COMPRESSION TANKS

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies providing compression tanks complete with fittings and appurtenances.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of the jurisdictional authorities.
2. ASME: Boiler and Pressure Vessel Code.

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:

a. Complete catalog information and shop drawings including piping diagrams.

PART 2 – PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. Compression Tank:

1. Compression tank diaphragm type.
2. Black-steel, welded plate with rustproof coating on exterior, capacity as shown.
3. Designed for working pressure of 125-psig minimum; meeting ASME Boiler and Pressure Vessel Code.
4. Diaphragm made of butyl, replaceable.
5. System connection forged steel.
6. Factory precharged to 12 psig.
7. Provided with charging valve and drain plug.
8. Tank shall have NPT system connection, glass gauge tapings and drain.
9. Tank shall be furnished with saddles.

B. Nameplates:

1. Securely attached plate on each tank showing manufacturer's name, model number and serial number.

PART 3 – EXECUTION

3.01 INSTALLATION:

A. Install equipment and appurtenances within space provided and locate for easy servicing.

B. Provide concrete pad, bracket supports, saddles and hangers for tanks.

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:

1. Insulation: Section 15080.
2. Vibration isolation: Section 15070.
3. Motors: Section 16225.

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:

1. Test pumps at 1-1/2 times working pressure.
2. 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:

1. 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 split case, vertical split case, or end suction 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 or end 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.
5. Provide suction guide and angle flange rated for a minimum of 150 psi.

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:

1) Temperature range: 40F to 225F.
2) Shaft sealing member: Buna rubber.
3) Rotating sealing member: Carbon.
4) Metal parts of seal: Brass.
5) Stationary sealing member: Nickel-alloy iron.
6) 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, drip proof and fully guarded.
3. Pump motor shall be be inverter duty type rated for operation with variable frequency drive.

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 on drawings.

G. Ensure that pump and motor operate without noticeable vibration after installation.

END OF SECTION

SECTION 15186A

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 15900A.

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 15900A.
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. The system shall be a packaged unit from the manufacturer.
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.
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.
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. Control panels provided shall comply with the reference drawings shown as part of the contract drawing package.

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 and as required per the manufacturer for a complete functional system. 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. Cold water metering cable should terminate in the chiller plant control panel.

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. Terminate water treatment loop piping in the water treatment panel as well as the chiller plant control panel.

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 15900A 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 five 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 spec Section 15900A and 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 (RS485 communications card shall be included).

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. RS485 communications card shall be included.
3. Cold-Water Meter: Positive-displacement type with sealed, tamperproof magnetic drive, impulse contact register. Terminate cold water meter cable in the chiller plant control panel. Include blow down meter and terminate in the chiller plant control panel.

   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 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 15900A and Contract Drawing.

   a. Control dissolved solids, based on conductivity, and include the following:

      1) HACH Controller, model SC 200 with ModBus Network Module
      2) Conductivity Sensor Module with Electrodeless Conductivity Sensors.
      3) Bleed-off light to indicate valve operation

9. Chilled Water and Condenser Water Loop Flowmeter: Provide Ultrasonic Non-intrusive Flowmeter, Siemens Sitrans FUS1010 (wall mounted) 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. Firestopping: Section 07841.
2. Field painting: Section 09920.
3. Identification of mechanical equipment and piping: Section 15075.
4. Insulation: Section 15080.
5. Grounding and bonding: Section 16060.

1.02 QUALITY ASSURANCE:

A. Qualifications of Welder: Section 05500.

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: B16.1, B16.5, B16.9, B16.11, B16.22, B16.39, B31.1, Z21.22.
7. ANSI/AWS: E8016, E8018.
8. AISI
9. FS: SS-C-153C, WW-P501, WW-U-516B, WW-U-531, WW-V-51F.
10. MSS: SP-58, SP-67, SP-70, SP-80.
11. ASTM: A53, A105, A126, A234, A276, A395, A536, B32, B61, B62, B88, B150, B306, F709.
12. U.L. Listed

    a. ANSI/ASME B16.9.

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:

    a. Complete catalog information and shop drawings for material and equipment.
    b. Submittals include, but are not limited to, the following:

        1) Pipes and piping layout, including locations of hangers and supports.
        2) Pipe hangers and supports.
        3) Valves.

4) Escutcheons.
5) Gauges.
6) Expansion joints, guides and anchors.
7) Air eliminators.
8) Pipe sleeves.
9) Drains.

2. Certification:

a. Certificates from manufacturers verifying the following:

1) That pipe-joint gaskets and lubricants are satisfactory for use with pipe and fittings specified.
2) That 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. 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 or otherwise inaccessible.

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.

2. Copper tubing and fittings:

a. Copper tubing for potable water and where embedded or otherwise inaccessible: ASTM B88, Type K, hard-drawn.
b. Provide copper tubing for potable water: ASTM B88.

1) Potable water: Type L.

2) Potable water: Type K, annealed and lengths of piping 100 feet or less continuous without joints.

c. Fittings for potable-water piping: ANSI/ASME B16.22.

1) Fitting wall thickness after forming not less than that of adjacent piping.

d. Solder joints: Lead-free 95.5-percent tin, 4.0-percent copper and 0.5-percent silver with non-corrosive flux; ASTM B32.

3. Copper drainage tube (DWV) and fittings:

a. Seamless tubing: ASTM B306, No. 122 for drainage, waste, and vent piping and fittings.

4. Condensate-drain pipes:

a. Hard-drawn copper: ASTM B88, Type L.

5. 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.

6. Black-steel seamless pipe and fittings:

a. Exposed chilled water, condenser-water supply and return piping: ASTM A53, Schedule 40.
b. Pipes 1-1/2 inch and smaller connected with socket-weld fittings or screwed 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.

7. 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, ASME-B16.39 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, A-A-59617.

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.

2. Gate valves 2-1/2 inches and three inches:

   a. MSS SP-70, Type 3, Class 125, OS&Y flanged end, Type I, Class 2, cast-iron bodies and bonnets.
   b. Seat rings, disc, disc guide and stem furnished in bronze.
   c. Outside stem and yoke (OS&Y), flanged-end connections and malleable-iron hand wheels.

3. 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.

4. Globe, angle and check valves:

   a. Two inches and smaller:

      1) MSS SP-80, Class 150.
      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.

         c) Outside arm and weight for pump discharge check valves.

5. 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: MSS SP-80, Bronze, Class B.

6. 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.
k.

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.

7. 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.

8. 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 tapings 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 tapings 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.

9. Refrigerant valves: UL listed.
10. 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.

11. 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 to12-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.

12. 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.

13. 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. Test shell at 225 psi.
    h. 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.

i. 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.

j. Disc:

1) Aluminum-bronze: ASTM B150.

k. Stem:
l. 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. ASME B40.100 Grade 1A, Class 1, 2 or 3, Style A, Type I or III with metal case.

I. 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 non-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.

J. Supporting Devices:

1. Pipe hangers and supports:

    a. Provide adjustable steel pipe hangers and supports as follows:

        1) Clevis and clamp, 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, zinc-hot dipped galvanized, threaded full-length and diameter required by pipe size and load imposed.
    d. Hanger rod nuts and washers: Steel, zinc-hot dipped galvanized.
    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 over travel 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. Sleeves shall be hot dipped galvanized.

    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.

K. 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.

L. Flexible Connectors:

1. Braided flexible connectors shall consists of braided metal hose, with inlet and outlet 150# carbon steel plate flange connections. The connectors shall be engineered to move laterally, absorb vibration and shall impart no thrust loads to system anchors.
2. Materials of construction of the braided connector hose to be corrugated stainless steel with a stainless steel braid.
3. Connectors shall be rated for atleast 150# design pressure and 120F temperature.

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. 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 20 psi at most remote fixture.

C. 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.

D. 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.

E. Pipe Anchors:

1. Securely anchor piping where shown and where necessary for proper installation to force pipe expansion in proper direction.

F. 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.

G. Pipe Sleeves:

1. Exterior walls:

a. Install as shown.
b. For cathodically protected pipe, test in accordance with Section 16060.

2. Interior walls:

a. Install as shown. Seal to maintain integrity of walls.

H. Plumbing-Fixture and Equipment Connections:

1. Make connections to wall-hung water closets and urinals with adjustable flanged nipples secured to chair supports, wax rings and rubber or impregnated-felt gaskets.
2. Face plate of carrier not more than six inches from back of finish wall.

I. 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.

J. 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.

K. 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.

L. Firestopping: Section 07841.

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.

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: 200-psi minimum.
   b. Ductile-iron pipe: 150 psi or 1-1/2 times maximum working pressure, whichever is greater, at lowest point in system.
   c. Potable-water piping: 1-1/2 times operating pressure but not less than 100 psi at topmost outlet.
   d. 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.

2. Ductile-iron pipe and black-steel piping:

   a. Use procedure specified for chilled-water and condenser-water piping embedded or otherwise inaccessible.

3. Potable-water piping:

   a. Use procedure specified for chilled-water and condenser-water piping embedded or otherwise inaccessible, except tests may be conducted in sections as long as no pipes or joints are left untested.

C. 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.
4. 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.

END OF SECTION

SECTION 15410

PLUMBING FIXTURES/ EQUIPMENT

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies providing plumbing fixtures, including emergency-eyewash.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of the jurisdictional authorities.
2. FS: WW-P-541/GEN, A-A-1154.
3. ASMEA112.19.2M
4. ADA.
5. ANSI: Z358.1.

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. Product Shop Drawings.
2. Certification.
3. Operation and Maintenance Manuals.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Ship products securely packaged and labeled for safe handling in shipment and to avoid damage and distortion.

B. Mark each item permanently and legibly with manufacturer's name, brand, reference specification, type, class and other pertinent information as applicable.

C. Store products in a secure, dry storage facility.

PART 2 – PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. Plumbing Fixtures/ Equipment:

1. General requirements:

a. A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

b. Use or reuse of components and materials without a traceable certification is prohibited. Brass fittings, faucets, traps and exposed piping, chrome-plated over nickel plate, with polished finish.
c. Brass pipe, chrome-plated over nickel plate and provided with heavy cast-brass escutcheons and set screw plated to match pipe at fixtures passing into floors, walls or partitions.

1) Utility Sink:

a) Fixture: Enameled cast iron with stainless steel rim guard and blank back.
b) Faucet: exposed top supplies, with hose threads, vacuum breaker, and rod support.
c) Accessories: 3-inch trap standard with grid strainer.

2) Instantaneous Electric Water Heater:

a) Description: UL listed, tankless with removable cover, replaceable heating element, immersion-type thermostat, replaceable inlet filter, and flow regulator.
b) Capacity: As shown on the drawing.

B. Fixture Supports:

1. Supports for wall-hung water closets, urinals and lavatories: FS WW-P-541/GEN.
2. Supports of metal, concealed in building construction. Fixtures rigidly supported from floor by means of one or more heavy extensions or feet built into floor.

C. Vacuum Breakers:

1. Chrome-plated brass sized to provide minimum air area equal to piping served and approved by local jurisdictional authorities

D. Traps:

1. Plain-pattern type having seal minimum of 2-1/2 inches and maximum four inches.
2. 1-1/2 inch and two-inch traps: Heavy cast brass.
3. All other size traps: Same material as specified for piping system to which they are connected.
4. Fixture traps: As specified under plumbing fixtures, and insulated in accordance with ADA guidelines.

E. Emergency Eyewash Fountain and Body Spray:

1. In accordance with ANSI Z358.1.

a. Permanent type:

1) Equipped with automatic pressure and volume-control devices to ensure safe and steady water flow under varying pressures.
2) Wall-mounted, with functional parts constructed of corrosion-resistant materials and as follows:

a) Eyewash fountain: Twin chrome-plated brass eyewash heads, angled to direct flow of water into eyes and ocular area of face and mounted in stainless-steel bowl.

3) Operated by valves of the following types:

a) Eyewash fountain: Push-flag operating handle on stay-open valve.

4) Water filter:

a) Made of FDA-approved polypropylene with disposable FDA-approved viscose-fiber filter media capable of removing particles larger than 20 microns.
b) Capable of withstanding rate of flow of seven gpm and working pressure of 80 psi at 100F.

PART 3 – EXECUTION

3.01 PREPARATION

A. Drawings do not attempt to show exact details of fixtures. Changes in locations of fixtures, advisable in opinion of Contractor, shall be submitted to Engineer for review before proceeding with the Work.

3.02 INSTALLATION:

A. Protection of Fixtures:

1. Protect plumbing fixtures from dirt, foreign objects and damage during construction period.
2. Do not use warped or otherwise imperfect fixtures.
3. Do not use installed fixtures for any purpose, except testing, prior to final acceptance by the Authority.
4. Replace damaged and defective fixtures.
5. Install vacuum breakers on water supply-piping connections to fixtures and equipment in accordance with requirements of jurisdictional authorities.

B. Emergency-Eyewash Facilities:

1. Install in locations shown and as follows:

a. Install water-supply line connecting facilities to water service.
b. Install filter on water-supply line at readily serviceable location.
c. Install drain line connecting facilities to drainage system as shown.

C. Safety Equipment:

1. System Shutoff Valves:

a. Shutoff valves shall give visual indication of position (open or closed).
b. Shutoff valves shall be lockable valves and locked in open position.

2. Eyewash shall have red safety signoff tag. After completing requirements listed below, Contractor and Owner shall sign red safety signoff tag. Requirements are as follows:

a. Visually check safety shower/eyewash piping for leaks.
b. Verify that upon operation, stay-open valves remain open.
c. Water arcs from eyewash spray heads must cross. Test with eyewash gauge; Haws Drinking Faucet Co., Model 9015.
d. Minimum flow rates for eyewashes shall be 3 gpm.
e. Tempered water temperature shall be between 65F – 80F.

D. Install, arrange, and connect equipment as shown on Drawings and in accordance with manufacturer's recommendations.

3.03 FIELD QUALITY CONTROL

A. Perform visual inspection for physical damage, blocked access, cleanliness, and missing items.

B. Notify Owner and Engineer 48 hours prior to eyewash testing. Owner and Engineer reserve the right to witness all tempered water testing.

C. Test eyewash units. Water flow must be tested at eyewash/face ring.

1. Eyewash Flow:

a. Test with tube-type water gauge (Haws Drinking Faucet Co., Model 9010) and 1-gallon container.
b. Container shall fill in 20 seconds or less.

2. Contractor shall log, date, and initial inspection upon passing flow tests.

D. Verify alarm operation both locally. Notify security prior to test if alarm is connected system-wide.

END OF SECTION

SECTION 15625

CHILLERS

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies providing complete factory-assembled packaged water-chilling units.

B. Related Work Specified Elsewhere:

1. Concrete pads: Sections 03300.
2. Water Treatment System: Section 15186A.
3. Piping systems: Section 15205.
4. Insulation: Section 15080.
5. Vibration isolation: Section 15070.
6. HVAC Instrumentation and Control: Section 15900A.
7. Wire, cable and busways: Section 16120.
8. Conduit, raceways and cabinets: Section 16130.
9. Motors: Section 16225.
10. Motor starters and control center: Section 16425.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards, and Specifications:

1. Comply with codes and regulations of the jurisdictional authorities.
2. ASME Section VIII Code.
3. AHRI: 550/590
4. ANSI: B9.1.
5. ASHRAE Standards.
6. UL/ ETL
7. NEC
8. OSHA

B. Design Criteria:

1. For single-chiller chiller plant: Select each water-chilling unit in accordance with the following criteria:

a. Water on evaporator: 55F.
b. Water off evaporator: 42F.
c. Water on condenser: 85F.
d. Water off condenser: 95F.
e. Net refrigeration effect, chilled-water flow rate and condenser water-flow rate: as shown on the Contract Drawings.
f. Control system compatible with AEMS system.

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.

    a. Capacity curves for evaporator/compressor and compressor/condenser plotted on charts to ensure properly balanced refrigeration equipment under design conditions.
    b. Dimensioned plan and elevation view, including required clearances, and location of all field piping and electrical connections.
    c. Summaries of all auxiliary utility requirements such as: electricity, water, air, etc. Summary shall indicate quality and quantity of each required utility.
    d. Diagram of control system indicating points for field interface and field connection. Diagram shall fully depict field and factory wiring.
    e. Manufacturer's certified performance data at full load plus IPLV or NPLV.

2. Certification.

    a. Record of packaged water chillers in field operation for minimum of 12,000 operating hours for not less than ten individual units prior to shipment. Types that have already shown satisfactory operation for this period may have modifications, provided modifications will not increase maintenance and operating costs or decrease life of machine and complies with AHRI 55/590; ARI 550.
    b. Verification of successful use of material used for impeller wheel for centrifugal compressors, if other than aluminum alloy.

3. Operation and Maintenance Manuals.

1.04 JOB CONDITIONS:

A. Safety Requirements:

1. Properly guard belts, pulleys, chains, gears, couplings, projecting set screws, key and other rotating parts to prevent danger to personnel.

1.05 OPERATION AND MAINTENANCE TRAINING:

A. In accordance with the General Requirements.

1.06 WARRANTY:

A. Equipment shall be provided with a five year entire unit parts and labor warranty. The chiller manufacturer shall cover parts, labor costs for the repair or replacement of defects in material or workmanship for a period of five years from equipment start up. Warranty shall include refrigerant.

1.07 DELIVERY AND HANDLING:

A. A. Chillers shall be delivered to the job site completely assembled and charged with refrigerant R134a and be shipped on skids with a weather resistant cover.

B. Comply with the manufacturer's instructions for rigging and transporting units. Leave protective covers in place until installation.

PART 2 – PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. General Requirements:

1. Provide complete water-cooled, semi-hermetic, oil-free, magnetic bearing, centrifugal compressor water chiller as specified herein. Supply chiller with full operating charge of HFC-134a Refrigerant. In design and purchase of equipment, provide for interchangeability of items of piping equipment, subassemblies, parts, motors, starters and relays. 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. Centrifugal Compressors:

1. The unit shall utilize two magnetic bearing, oil-free, semi-hermetic centrifugal compressors.
2. Single-stage, statically and dynamically balanced impeller.
3. Casing fabricated of cast iron, aluminum or steel plate with split sections gasketed and bolted.
4. Impeller wheel constructed of aluminum alloy or other material that has been demonstrably successful in use.
5. Impeller shaft fabricated of heat-treated alloy steel with sufficient rigidity for proposed operation at specified operating speeds.
6. 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. Capacity reduction designed to provide automatic capacity modulation from 100 percent capacity to 10-percent capacity without cycling.
7. Capacity-control system actuated by temperature of water leaving evaporator.
8. Transducers for remote surveillance and control by Chiller plant monitoring panel system and capability to send signal to the AEMS as shown and in accordance with Section 15900A.

C. Water Cooler/ Evaporator:

1. Removable bundle-type copper tube, constructed of seamless copper tubing minimum 0.035-inch wall thickness, plain or with integral fins individually replaceable and rolled or brazed into copper or steel-tube sheets, with baffles and tube supports of copper or steel.
2. Complete refrigerant-feed control, designed to control feed to evaporator at each level of load range from 100 percent to 10 percent of package water-chilling capacity without use of hot-gas bypass.
3. Performance based on water velocity of minimum three fps and maximum ten fps throughout full length of tubes and fouling factor of 0.00025 for individual machine.
4. Water spaces in coolers designed for minimum 150-psi working pressure; tested in accordance with ASME Code.
5. Water spaces not subject to the ASME Code due to size or other limitations, tested at pressure of not less than 1-1/2 times working pressure.
6. 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.
7. 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.

D. Insulation:

1. Each water-chilling unit provided with insulation as specified in Section 15080.

E. Condenser:

1. Shell-and-tube type permitting tubes to be cleaned from each end by removing water-box cover plates or head.
2. The tubes shall be individually replaceable and secured to the intermediate supports without rolling or expanding to facilitate replacement if required.
3. Tubes fabricated of seamless copper tubing, minimum 0.035-inch wall thickness, with integral fins individually replaceable and rolled or brazed into copper or steel-tubed sheets.
4. Performance based on rate of water flow specified and water velocity of 3-fps minimum and 10-fps maximum throughout full length of tubes and fouling factor of 0.00075.
5. Water spaces in condenser designed for minimum 150-psi working pressure; tested in accordance with requirements of ASME Code.
6. Refrigerant side of shell tested at 1-1/2 times refrigerant saturation pressure.
7. 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.
8. 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.

F. Compressor Drive Motor:

1. Squirrel-cage induction, refrigerant gas-cooled, rated at 460 volts, three-phase and 60 Hertz and in accordance with Section 16225.
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. Motor starter conforming to recommendations of water-chiller manufacturer and as specified in Section 16425.
4. Wiring as recommended by compressor manufacturer to provide complete automatic operation of centrifugal refrigeration system.

G. Controls, Control Panel and Gauges:

1. Provide a microprocessor control panel which can monitor and display various chiller parameters and alarms, with a touchscreen operator interface and an unit controller. As a minimum, monitor the following points at the Chiller plant monitoring panel:

a. Analog points:

1)	Chilled water enter temperature	DEG F
2)	Chilled water leaving temperature	DEG F
3)	Condenser water entering temperature	DEG F
4)	Condenser water leaving temperature	DEG F
5)	Condenser water pressure	PSI
6)	Chilled water pressure	PSI
7)	Condenser refrigerant pressure	PSI

8)	Evaporator refrigerant pressure	PSI
9)	Percent of 100% speed (per compressor)	%
10)	Chiller KW demand	KW
11)	Chiller efficiency	KW/TON
12)	Chilled water flow	GPM
13)	Condenser water flow	GPM
14)	Refrigerant Purge Air Pressure	PSI
15)	Condenser water pressure flow differential	PSI
16)	Chiller Oil Pressure	PSI
17)	Outdoor Temperature	Degree F
18)	Outdoor Humidity	0-100%
19)	Chiller Plant Space Temperature	Deg F
20)	Chiller Voltage	V

b. Status Points (Contact Closure):

1) Chiller Motor ON/OFF
2) Condenser Water Pump ON/OFF
3) Chilled Water Pump ON/OFF
4) Cooling Tower Fan ON/OFF
5) Chiller Refrigerant Purge Air Pump ON/OFF
6) Chiller NORMAL/ ABNORMAL
7) Chiller Condenser Water Flow NORMAL/ ABNORMAL
8) Control Air Pressure NORMAL/ ABNORMAL
9) Chiller Plant Space Temperature NORMAL/ ABNORMAL
10) Condenser Water Pumps HOA Selector
11) Switch AUTO/HAND
12) Chilled Water Pumps HOA AUTO/HAND
13) Selector Switch
14) Cooling Tower Fans HOA AUTO/HAND
15) Selector Switch

c. Control Points (Contact Closure):

1) Chiller Motor ON/OFF
2) Condenser Water Pumps ON/OFF
3) Chilled Water Pumps ON/OFF
4) Cooling Tower Fans ON/OFF and speed control based on condenser water temperature.

d. Alarm points:

1) Chiller bearing temperature
2) Compressor failure

e. In addition, for future interface with an Energy Management System, provide a 4-20 mA signal output for each analog point and a dry contact closure for each alarm point.

2. Capacity-control mechanism to be integral part of packaged water chiller maintaining leaving water temperature within 0.75 degrees F of setting temperature from 100 percent to 10 percent of chiller capacity.
3. Control mechanism: Compressor stopped when chiller output drops below 10 percent and automatically restarted when leaving water rises to preset temperature.
4. Timing device: Restarting unit limited to four starts per hour, minimum 15 minutes apart.

5. Modulating chilled-water operating control having adjustable throttling range, with means of calibration by adjusting chilled-water temperature control point. Solid-state electronic control.
6. Control panel provided on each unit with compressor-operating control, START/STOP switch and the gauges and protective devices as per paragraph G-1.
7. Signal lights for protective devices.
8. Alarm-circuit terminals in basic chiller-package control panel designed to actuate alarm device in event of machine cutout of protective devices.
9. The chiller shall be capable of automatic control of: evaporator and condenser pumps (primary and standby), cooling tower fan cycling control and a tower modulating bypass valve or cooling tower fan variable frequency drive.

H. Evacuation System:

1. Manually started and stopped evacuation system when positive-pressure refrigerant is used and chiller package is not designed to permit pumpdown storage and isolation of entire charge in condenser.
2. Motor-driven, air-cooled or water-cooled reciprocating condensing unit and receiver of sufficient capacity to store entire refrigerant charge of largest water-chilling system.
3. Receiver in accordance with ASME Code, mounted on floor brackets and provided with rupture members and dual relief valves in series.
4. Entire system completed with valves, piping and controls so that evacuation system may be utilized for pumpout, without temporary piping or wiring.

I. Receiver, Refrigerant:

1. Horizontal liquid receiver designed, fitted and rated in accordance with ASME Code.
2. Each receiver having storage capacity 25 percent minimum in excess of that required for fully charged system.
3. Inner surfaces thoroughly cleaned by sandblasting.
4. Each receiver equipped with inlet, outlet drip pipe, drain plug, purging valve, relief valves of capacity and setting in accordance with ANSI B9.1 and two bulls-eye liquid sight glasses.
5. Sight glasses installed in same vertical plane, 90 degrees apart, perpendicular to the axis of the receiver and not over 3-inches horizontally from drip pipe measured along axis of receiver.
6. Receiver constructed and tested in accordance with ASME Code.

J. Starter:

1. Motor starters: Section 16425.

K. Tools:

1. One complete set of special tools as recommended by manufacturer for field maintenance of system.

L. Factory Wiring:

1. In accordance with manufacturer’s standard practice.

M. Nameplates:

1. Securely attached to each chiller showing manufacturer’s name, model number and serial number.

N. Power Connection:

1. Provide single point power connection with non-metal compressor conduits and disconnect switch.

O. Vibration Isolation:

1. Provide as required in specification section 15070.

P. Refrigerant Leak Detection System:

1. Provide refrigerant leak detection sensors suitable for R-134A per ASHRAE-15 requirements and code compliance.
2. Provide refrigerant leak detection panel, quantity as required for a complete functional system, with a capability to provide audible and visual alarm and integrated to the exhaust system.

PART 3 – EXECUTION

3.01 INSTALLATION:

A. Fit equipment and appurtenances within space provided and make readily serviceable. Install per manufacturer's requirements, shop drawings, and contract documents.

B. Provide concrete pads, platforms and hangars necessary for proper installation of equipment.

C. Install chillers on concrete pads 4-inches minimum height in accordance with Sections 03100 and 03300.

D. Install chillers on vibration Isolators in accordance with Section 15070.

E. Coordinate work with other trades.

F. Mount tools on tool board in equipment room, as directed.

G. For piping system installation, see Section 15205.

H. For water treatment installation, see Section 15186A.

I. For conduit, raceways and cabinets installation, see Section 16130.

J. For wire cable, and busways, installation, see Section 16120.

3.02 FIELD SERVICES:

A. Semi-Hermetic Units: Obtain on-site services for two man-days (regular working hours) of manufacturer’s engineering representative to advise on the following:

1. Pressure test on semi-hermetic water-chilling unit for leaks.
2. Evacuation and dehydration of machine to minus 12F wet bulb or to absolute pressure of not over 0.204-inch of mercury for 24 hours minimum.
3. Charging machine with refrigerant.
4. Starting machine and instructing representative of the Authority as to its proper care and operation. Provide factory startup personnel 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.

B. Open Units: Obtain on-site services for two man-days (regular working hours) of manufacturer's engineering representative to advise on the following:

1. Erection, alignment, testing and dehydrating.
2. Charging machine with refrigerant.
3. Starting machine and instructing Authority personnel in proper care and operation of machine.

END OF SECTION

SECTION 15640

COOLING TOWERS

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies providing factory-assembled, counterflow, vertical-discharge, induced draft, cooling towers.

B. Related Work Specified Elsewhere:

1. Piping systems: Section 15205.
2. Vibration isolation: Section 15070.
3. Sound attenuators: Section 15825.
4. HVAC Instrumentation and Control: Section 15900A.
5. Motors: Section 16225.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards, and Specifications:

1. Comply with codes and regulations of the jurisdictional authorities.
2. NFPA: 214.
3. CTI: Bulletin ATP-105.
4. ASME: Performance Test Code PTC-23.
5. ASTM: A653, B117.

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. Certificates stating that the sound power level of cooling tower based on 10-12 watts does not exceed following decibel ratings, without attenuators:

Octave Band Center Frequency/Hertz	Sound Power Level/dB
63	97
125	95
250	92
500	90
1000	86
2000	85
4000	82
8000	78

b. Certified field test reports as specified and as directed.

3. 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.

1.05 OPERATION AND MAINTENANCE TRAINING:

A. Upon completion of installation, furnish on-site services of manufacturer's engineering representative with specialized experience in components of system for minimum of 1/2 man-day (regular working hours) to instruct Authority personnel in proper operation and maintenance of each system.

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, motor starters and relays.
2. Type 304 and/or Type 316 Stainless steel.

B. Cooling Towers:

1. Each cooling tower designed to meet the following performance criteria:

a. Water-flow rate: As shown.
b. Cooling: From 95F to 85F minimum.
c. Ambient temperature: 78F wet bulb.
d. Water-pressure drop: Not exceeding value shown on equipment schedule.

2. Sump sections:

    a. Stainless steel, heavy-gauge.
    b. Provided with outlet connection, overflow, valved drain and electric water-level control consisting of magnetic-type electric float switch in moisture proof housing and control solenoid valve in makeup water line.
    c. Outlet connections with large-area lift-out strainer with perforated openings sized smaller than spray-nozzle orifices, mounted in assembly and baffled to prevent cavitation.
    d. Pipe drain and overflow connections as shown or to nearest drain leading to sewer.

3. Fan sections:

    a. Fan material: Aluminum.
    b. Fans: Axial propeller-type statically and dynamically balanced.
    c. Designed to overcome resistance of tower, its enclosure, connecting ductwork and sound attenuators, if any, and quiet in operation.
    d. Air inlets designed for smooth air entry.
    e. Hot-dip galvanized bird screen at fan air inlets.

4. Fan bearings

    a. Heavy-duty ball bearings, precision-grade, incorporating cast-iron pillow blocks and self-aligning with wide inner rings for greater load capacity.
    b. Slip-fit bearings equipped with eccentric locking collars to provide for positive means of securing bearings to shaft.
    c. Prelubricated bearings, ready for immediate service.
    d. Grease-fitting for relubrication.
    e. Lithium-base grease, waterproof, containing inhibitor and effective for temperature range of minus 65F to plus 250F.

5. Fan drives:

    a. Fan: Gear driven by electric motors.
    b. Entire fan drive: Gear driven and other items manufacturer-rated for minimum of 1.5 times maximum horsepower required to drive fan.
    c. Rating taken from manufacturer's standard catalog data.
    d. Direct drive compatible with variable frequency drive.

6. Fan motors: Section 16225, with the following additional requirements:

    a. Four-pole, totally enclosed, fan-cooled, inverter duty rated and guarded.

7. Casings:

    a. Fabricated of heavy-gauge hot-dip galvanized steel using channel-type sheets.
    b. Gasketed access doors for strainer.
    c. Towers designed for live load of 40 pounds per square foot on horizontal deck surfaces and wind load of minimum 100 miles per hour for vertical surfaces.

d. Ladder: Aluminum or hot-dip galvanized steel for towers having water-distribution section more than eight feet above roof or grade.

8. Tower fill and drift eliminators:

   a. Tower fill (wet deck) fabricated in modular layers consisting of manufacturer recommended plastic, wave-formed, surface sheets or manufacturer's equivalent standard product.
   b. Drift eliminators fabricated of materials specified for fill but located at top of tower and assembled in easily handled removable sections to provide access to spray tree and nozzles.

9. Water distribution:

   a. Water evenly distributed over tower fill area through spray tree consisting of hot-dip galvanized steel header and removable hot-dip galvanized steel branches.
   b. Branches and spray nozzles retained in place by means of snap-in rubber grommets to provide for ease of removal for cleaning and replacement of spray nozzles.
   c. Plastic nozzles provided.
   d. Spray tree and spray nozzles designed for total flow rate for each tower as specified.
   e. Spray header with plugged tap for measurement of pressure.
   f. Separate regulating and stop valves for complete balancing and complete shutoff for each tower.

10. Makeup-water solenoid valve:

    a. 120-volt, 60-Hertz solenoid valve installed in makeup-water line.
    b. Maximum operating pressure-drop across valve: 10 psi.
    c. Solenoid valve controlled by electric float switch.

C. Nameplates:

1. Securely attached plate on each cooling tower showing manufacturer's name, model number and serial number.

D. Sound Attenuators: Section 15825.

E. Controls: Section 15900A.

F. Vibration Isolators: Section 15070.

PART 3 – EXECUTION

3.01 INSTALLATION:

A. Start ladders at roof or grade level.

B. Provide support beams, concrete pads, platforms, hangers and anchor bolts for proper installation of equipment as recommended by the manufacturer.

C. Install complete potable makeup-water system as shown on the drawings and piping materials as specified in Section 15205.

D. Mount units on vibration isolators in accordance with Section 15070.

E. Provide sound attenuators where shown.

3.02 FIELD QUALITY CONTROL:

A. Field Tests:

1. Test cooling towers in accordance with ASME Performance Test Code PTC-23 or CTI Bulletin ATP-105, using services of independent testing agency.
2. Prior to commencing tests, submit name of testing agency for approval.
3. Tests will be observed by the Authority and calculations performed immediately following tests. Have tests and calculations signed by observers.
4. Submit computations to the Engineer together with six complete sets of test results.
5. Compute and test in accordance with particular test procedure employed by testing agency.
6. When the Engineer considers the performance of cooling towers unsatisfactory, the Engineer will direct that cooling towers be retested.
7. Should tests show that cooling towers are deficient, modify or replace towers to provide specified capacities.
8. If cooling tower performance is proven satisfactory, cost of tests will be borne by the Authority. If cooling tower performance is proven unsatisfactory, cost of tests will be borne by the Contractor.

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. HVAC Instrumentation and Control: Section 15900A.
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. AHRI: 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 AHRI 430 and AHRI 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, air filter 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 shall have 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: 150 psig, 55℉. Sweat type connections are standard.

E. Drain Pan

1. The drain pan is noncorrosive and double-sloped to allow condensate drainage.
2. The drain pan 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 filter 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 circuit setter, three-way control valve, strainer, and ball isolation valves.
2. The maximum entering fluid temperature to the water valves is 55℉.
3. All chilled water piping and accessories shall be insulated.

I. Control Interface

1. Air handler shall be equipped with a control interface is intended to be used with a field-supplied, low-voltage thermostat.
2. Control interface for fan control shall be as per the sequence of operation called out on the drawings.

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 15765

HEATING EQUIPMENT

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies providing heating equipment and electric heat tracing for piping.

B. Related Work Specified Elsewhere:

1. Vibration isolators: Section 15070.
2. HVAC Instrumentation and Control: Section 15900A.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of the jurisdictional authorities.
2. UL: 1025.

B. Source Quality Control:

1. Test electric heating coils dielectrically at 2,000 volts before shipment.

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. Successful dielectric testing of electric heating coil at 2,000 volts.

3. Operation and Maintenance Manuals.

PART 2 – PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. General Requirements:

1. In design and purchase of equipment, provide for interchangeability of items of equipment, subassemblies, parts, motors, starters and relays.

B. Electric Unit Heaters:

1. Factory-assembled unit heaters consisting of heating element, fan, fan motor, housing and outlet diffuser.

a. Casings:

1) Fabricated of galvanized steel or bonderized steel, factory-primed and finished with baked enamel.
2) Parts rigidly stiffened to prevent vibration and to hold working parts in line.
3) Casings for suspended-type units designed for direct attachment to hangers.
4) Ceiling or wall-mounted, spring-type brackets furnished as necessary to support unit.
5) Casings readily removable for access to interior parts.
6) Adjustable horizontal vanes, arranged to give uniform air distribution without objectionable drafts.

b. Fan and fan motor:

1) Propeller fan directly connected to fan motor.
2) Fan factory-balanced dynamically and designed for quiet operation.
3) Unit heater/fan motor: As standard with manufacturer.
4) Each unit equipped with combination fan guard/motor support resiliently mounted to absorb motor vibration.
5) Motor speed: 1,750-rpm maximum.
6) Integral transformer where fan-motor voltage differs from line voltage.

c. Heating element:

1) Resistance wire of corrosion-resistant metal surrounded by finned metal sheath, interspace filled with ceramic material or magnesium oxide.
2) Each heating element wired to built-in, line-voltage, automatic-reset, thermal-overheat protection.
3) Complete controls, contactors, control-circuit transformers factory-assembled and factory-wired.
4) Unit heaters tested and listed under UL 1025.
5) Thermostats: Built-in, unless otherwise shown.
6) Disconnect switch near unit heater.
7) Starter and Disconnect by manufacturer.

d. Unit heaters with capacities of 10 kW or higher equippped with H.O.A. switches.

C. Electric Heat Tracing for Piping:

1. Heat-traced pipe insulated after installation of heating tape in accordance with Section 15080.
2. Heating tape with single or twin heating elements embedded in impact-resistant, high-dielectric refractory material, UL-listed and with stainless-steel exterior protective sheath acting as electrical ground in case heating element touches sheath.
3. Heating tape rated for voltage shown and capable of producing wattage shown.
4. Heating tape flexible with minimum bending radius of not more than six times diameter of tape.
5. Heating tape compatible with pipe temperature-sensing thermostat: Section 15900A.
6. Heating tape connected to power source and controls through nonheating leads minimum seven feet in length.

D. Nameplates:

1. 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. Mount electric unit heaters on vibration isolators in accordance with Section 15070.

C. Provide supports, hangers and anchor bolts necessary for proper installation of equipment as recommended by manufacturer

D. Provide heat tracing on piping where shown.

E. Install electric heating coil where shown.

F. Apply insulation on heat-traced piping in accordance with manufacturer's recommendations.

1. Where heating tape is spiraled, ensure that adjacent turns do not touch so as to avoid overheating and damaging sheath material.
2. Allow minimum of one inch between spirals.
3. Do not flex wire when ambient temperature is less than 32F, unless tape is warmed.
4. Connect unheated cold end to power source.
5. Secure heating tape in contact with pipe with banding or strapping.
6. Provide automatic temperature control by thermostat designed and set to energize at 40F.
7. Upon completion of installation and testing of pipe, install and test heating tape in accordance with manufacturer's recommendations.

END OF SECTION

SECTION 15810

DUCTWORK

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies providing ductwork and accessories.

B. Related Work Specified Elsewhere:

1. Firestopping; Section 07841.
2. Insulation: Section 15080.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of the jurisdictional authorities.
2. SMACNA:

   a. HVAC Duct Construction Standards - Metal and Flexible.
   b. Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems.
   c. HVAC Systems - Testing, Adjusting and Balancing.
   d. HVAC Air Duct Leakage Test Manual.

3. ASTM: A36, A53, A653.
4. NFPA: 90A
5. AASHTO: M81.
6. UL: Building Materials Directory, 181, 555.

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:

   a. Scale: 1/4-inch minimum

2. Certification.

PART 2 – PRODUCTS

2.01 MATERIALS:

A. Galvanized Sheet Steel: ASTM A653.

B. Steel Plate: ASTM A36, Grade A.

C. Steel Pipe: ASTM A53, Grade A.

2.02 FABRICATION:

A. Duct Construction:

1. Fabrication in accordance with SMACNA HVAC Duct Construction Standards-Metal and Flexible.

B. Access Doors in Ducts:

1. Provide access doors to gain access to fans, fan motors, dampers, filters, coils and controls in field verified accessible locations.
2. Doors: Of same metal thickness as ducts.
3. Gasketed doors: Secured to duct.

C. Plenums:

1. Field-fabricated and reinforced consistent with class of ductwork in which used.
2. Outward-opening access doors to plenums provided where necessary for equipment access and as shown.

D. Dampers:

1. Splitter or butterfly damper provided in duct leading to air terminal and branch duct take off from the main irrespective of whether shown on the drawings or not.
2. Butterfly dampers:

   a. Balanced-type with flat blades.
   b. Rigid blades fabricated with close-fitting hemmed edges.
   c. Damper rods minimum 3/8-inch square at one end passing directly through ducts.
   d. Square end of each rod held in self-locking lever device.
   e. Where installed in furred ceilings, damper-locking device may be provided with short lever and concealed in box with flush cover in lieu of access panel.

3. Opposed-blade dampers:

   a. Gang-operated multiple blades provided in ducts over 12 inches in dimension.
   b. Multiple blades fabricated maximum six inches wide.
   c. Fabricated with nonmetallic edges or coating in low-pressure, medium-pressure or high-pressure ducts.
   d. Ends of damper rods sealed to prevent leakage of air.

4. Splitter dampers:

   a. Single blade with hemmed edges, provided at branch duct connections.
   b. Each blade hinged at one end with sheet metal straps.
   c. Free end of each blade connected to 1/4-inch adjusting rod secured to side of duct in flanged bushing with set screws.
   d. Rods adjusted to operate freely between open and closed positions.

5. Damper material:

   a. Splitter and damper blades fabricated of same metal and two gauges heavier than ductwork and casings.
   b. Fastening details and other items fabricated of metal specified for ductwork and casing bracing.

6. Damper regulators:

    a. Self-locking, damper and splitter regulators furnished, labeled SHUT and OPEN.
    b. Factory-fabricated damper and splitter hardware furnished with zinc protective coating.

7. Fire dampers:

    a. Fabricated to meet requirements of codes and regulations of jurisdictional authorities.
    b. Constructed so that, during normal operation, folded blade assembly does not interrupt air stream.
    c. Access provided for replacement of links.
    d. Sleeve provided for fire damper, 14-gauge hot-rolled steel.
    e. Fire dampers remote from fire partitions; connecting ductwork provided between fire damper and fire partition, fabricated of 11-gauge, zinc-coated sheet steel and supported by ½-inch diameter rods.
    f. Fire dampers constructed to meet requirements of NFPA 90A and UL 555.

E. Flexible-Duct Connections:

1. Flexible-duct connections provided between air-handling unit fan and related ductwork and wherever necessary to prevent transmission of vibration to adjacent elements.
2. Factory-assembled flexible material bordered each side with three-inch wide galvanized-steel edging mechanically attached.
3. Width of flexible portion: Three to nine inches as necessary for installation conditions and to allow freedom of movement without unnecessary slack.
4. Fabric parts of flexible connections: Unpainted.

F. Instrument Test Holes:

1. Factory-fabricated, airtight, non-corrosive instrument test hole with screw cap and gasket.
2. Instrument test holes provided where required by balancing and testing agency.
3. Cap extended up through insulation.

PART 3 – EXECUTION

3.01 INSTALLATION:

A. Ductwork Installation:

1. Install dampers and splitters so as to permit adjustment after completion of the work.
2. Install dampers without strain or distortion of any part of dampers.
3. Adjust moving parts to move freely without binding.
4. Caulk dampers airtight around frames.
5. Adjust damper and splitter adjusting rods to operate freely between open and closed positions.

    a. Cut off projecting ends of rods after adjustment and bend over two inches from bushings.
    b. Leave cut ends smooth and free from burrs.

6. Where diffuser is located at end of rectangular duct, extend duct minimum of one-neck diameter beyond center line of neck.

7. Fire dampers:

    a. Install fire dampers in ducts which penetrate walls or floors separating areas normally used by the public from ancillary areas. Patron-used areas include, but are not limited to, the following:

        1) Station train rooms.
        2) Train tunnels.
        3) Passageways ordinarily used by patrons.

    b. Install fire dampers in ducts which penetrate walls and floors of elevator machinery rooms.
    c. Install fire dampers to conform with fire, smoke and radiation damper installation guide for HVAC system

8. Embedded Ductwork:

    a. Join sections by continuous weld to achieve water-tightness.

9. Duct penetration through fire-rated partitions to be sealed with approved fireproof sealant in accordance with Section 07841.
10. At in-line fans, provide flanged removable transition to permit access to and removal of fan motor

B. Flexible Connections:

1. Install flexible connections in accordance with SMACNA HVAC Duct Construction Standards – Metal and Flexible.

C. Protection of Ductwork:

1. Protect ductwork, appurtenances and openings from dirt, foreign objects and damage during construction.
2. Replace damaged ductwork and appurtenances.
3. Provide sheet metal caps on duct ends that are to be connected to future ductwork.

3.02 FIELD QUALITY CONTROL:

A. Air-Leak Tests for Accessible Ductwork: Perform air-leak tests in accordance with SMACNA HVAC Air Duct Leakage Test Manual.

B. Air-Leak Test for Embedded Ductwork: Test ductwork with internal air pressure of two inches wg. In accordance with SMACNA.

3.03 CLEANING OF AIR SYSTEM:

A. Before fans or filters are operated, clean inside of air system, including casing, plenums, ductwork and concrete tunnels/ air shafts used for air supply or return.

B. Accomplish cleaning by means of industrial vacuum cleaners which will effectively remove dust and foreign material from surfaces swept by air stream.

C. Clean exposed ductwork and leave in satisfactory condition, free from grease, oil and foreign material prior to application of insulation or finish painting.

D. Clean ducts after the system has been used for adjusting, testing or temporary ventilation.

END OF SECTION

SECTION 15825

SOUND ATTENUATORS

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies providing factory-fabricated sound attenuators.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of the jurisdictional authorities.
2. AMCA Standards.
3. SMACNA HVAC Duct Construction Standards.
4. UL: 723.
5. NFPA: 255.
6. ASTM: E84.

B. Source Quality Control:

1. Run tests for cooling tower fan attenuators on dynamic insertion-loss performance by duct-to-reverberation-room method with air flowing through sound attenuator at rated capacity.
2. Test methods to eliminate effects due to end reflection, vibration, flanking transmission and standing waves in reverberant room.
3. Take air flow and pressure loss data in accordance with AMCA Standards.

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. Certify that values for sound-pressure levels, i.e., decibels, Re 0.0002 microbar, of cooling tower with attenuators do not exceed those scheduled below measured at 50 feet in free field in any direction.

Octave Band Center Frequency/Hertz	Sound Pressure Level/dB at 50 Feet with Inlet and Outlet Attenuators
63	66
125	61
250	54
500	45
1000	42
2000	41
4000	39
8000	39

PART 2 – PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. General Requirements:

1. In design and purchase of equipment, provide for interchangeability of items of equipment, subassemblies and parts.

B. Cooling-Tower Sound Attenuators:

1. Factory-fabricated, packaged-type, furnished by tower manufacturer.
2. Outer casing constructed of minimum 22-USSG, hot-dip galvanized sheet steel in accordance with SMACNA HVAC Duct Construction Standards.
3. Panels lines:

   a. With weatherproof, inorganic, permanently odorless, fibrous-glass acoustic material.
   b. Combination rating when tested in accordance with ASTM E84, NFPA 255, or UL 723, maximum 25 for flame spread, 20 for smoke developed and 20 for fuel contributed.

4. Lining secured in place with galvanized-steel screening.
5. Removable panels: For access to the eliminator sections and upper interior of tower.
6. Exposed metal surfaces finished with zinc-chromate aluminum paint or manufacturer's standard finish providing equal or greater corrosion protection.
7. Intake attenuators designed to bolt directly to the cooling tower, having removable access doors at ends for entry to moving parts of unit.
8. Discharge attenuators designed to mount directly to top of tower and requiring no additional structural support.
9. Galvanized-sheet-metal hooded inlet provided for protection from weather.

C. Nameplates:

1. Securely attached to each attenuator showing manufacturer's name, model number and serial number.

PART 3 – EXECUTION

3.01 INSTALLATION:

A. Fit sound attenuators within space available without restricting air flow.

B. Install attenuators in accordance with manufacturer's recommendations and printed instructions.

C. Provide self-supported cooling tower attenuators which can be readily attached.

TABLE 15825-1 MINIMUM DYNAMIC INSERTION LOSS

Std. 8000 Type Hz	Max. Press. Length Ft.	Drop In.- -wg.	Dynamic Insertion Loss/Hertz 125 Hz	250 Hz	500 Hz	100 Hz	2000 Hz	4000 Hz
3A	3 8	.31	5	8	15	16	14	10
5A	5 10	.31	8	13	25	28	21	14
7A	7 12	.31	9	18	31	38	28	18
3B	3 11	.31	7	12	19	24	23	18
5B	5 14	.37	10	18	30	42	33	23
7B	7 18	.40	14	24	36	48	44	31

END OF SECTION

SECTION 15830

FANS

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies providing fans.

B. Related Work Specified Elsewhere:

1. Vibration isolation: Section 15070.
2. Ductwork: 15810.
3. HVAC instrumentation and Controls: Section 15900A.
4. Motors: Section 16225.
5. 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. AISI Standards.
3. AMCA: 210, 99-2408.
4. NFPA: 130.
5. SAE: 1035,1040.

B. Factory Wiring:

1. In accordance with manufacturer's standard practice.

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:

a. Performance tests certified by AMCA or performed either in accordance with AMCA 210 or in a laboratory approved by AMCA, for capacities shown.
b. Performance curves for each fan showing brake horsepower, static pressure and static efficiency plotted against air volume and noise level. For reversible fans, submit curves for both forward and reverse modes.

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 equipment, subassemblies, parts, motors starters and relays.
2. Requirements of this section apply to fans which are not a component part of air-handling units designed as complete units by the manufacturer.
3. Fan rating based on tests performed in accordance with AMCA 210.
4. Fans statically and dynamically balanced and quiet in operation.
5. Fans designed to ensure that resonance frequency of blade assembly is not within 15 percent of harmonics of rotational frequency.
6. Finished parts of fans, such as shafts and bearings, protected from rust prior to operation by means of wrappings or protective grease or plastic coatings.
7. Exhaust fan shall be provided with fire-stats to stop fan when temperature of air being handled reaches 125F.

    a. Fire-stat having adjustable range from 100F to 200F and manual reset.

8. Fans with wheels less than 12 inches in diameter, and utility fans operating at less than 0.75 inches WG may have forward-curved blades.
9. Fan construction suitable for operating conditions defined in AMCA 99-2408.

B. Axial Fans:

1. Direct-driven.
2. Welded tubular-steel casings
3. Equipped with stationary discharge conversion blades and adjustable motor mounts.
4. Air-foil blades: High-strength cast aluminum or steel.
5. Blade pitch:

    a. Fans with wheels 18 inches or larger: Blades field-adjustable without removing wheel from casing.
    b. Fans with wheels less than 18 inches in diameter: May be equipped with stationary blades.

6. Flanged-type for fan-casing connections to ductwork.
7. Internal and external belt guards, as appropriate.
8. Inlets with smooth, rounded edges.
9. Direct-driven fans:

    a. Provide with high-grade, steel fan shaft accurately machined and ground for proper fit to wheel hub and bearings.
    b. Fan bearings and drive shafts enclosed and isolated from the air stream.
    c. Bearings sealed mechanically against dust and dirt, self-aligning and grease-lubricated.
    d. Fan driven by motor rated at 150 percent of driving-motor brake horsepower.

10. Motors:

    a. 1/2 horsepower and above:

        1) Direct-driven fans: Totally enclosed, air-over, fully guarded in accordance with

Section 16225.
2) Motor shall be inverted duty rated compliant with a variable frequency drive.
3) Disconnect provide by fan manufacturer.

b. Less than 1/2 horsepower: Manufacturer's standard for intended use.

PART 3 – EXECUTION

3.01 INSTALLATION:

A. Fit fans and appurtenances within space provided and make readily serviceable.

B. Provide support beams, concrete pads, support legs, platforms, hangers and anchor bolts required for proper installation of equipment as recommended by manufacturer.

C. Vibration isolation for fans: As specified in Section 15070.

D. Concrete pads: As specified in Section 15070.

E. Axial and tubular centrifugal fans: Provide service access in accordance with Section 15810

F. Motor starters and control centers: As specified in Section 16425.

END OF SECTION

SECTION 15850

OUTLETS AND GRILLES

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies providing outlets and grilles.

B. Related Work Specified Elsewhere:

1. Ductwork: Section 15810.
2. 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.

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. Samples:

    a. One full-size sample of each outlet and grille in each finish specified.

3. Certification.

PART 2 – PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. Supply/Exhaust Grilles:

1. Type: Removable core, adjustable, two-way directional.
2. Horizontal adjustment: By means of individually adjustable vertical bars or vanes spaced one-inch apart maximum.
3. Vertical adjustment: By means of individually adjustable horizontal bars or vanes placed in front of vertical bars or by means of fixed fins which can be removed as a unit from frame and inserted in four positions.
4. Fixed fins spaced 1/4-inch apart maximum.
5. Frames constructed of stamped-steel or rolled-steel sections.

    a. Prior to priming and finishing, steel parts of grilles treated with zinc-phosphate or zinc-chromate, dipped after fabrication.

6. Grilles provided with airtight felt, neoprene or plastic sealing strips at edges, designed to prevent leakage.
7. Corner joints finished to provide neat, trim appearance.
8. Each grille provided with factory-fabricated volume-control damper furnished by grille manufacturer.

    a. Volume dampers: Group-operated, opposed-blade, key adjustable.
    b. Volume adjustment: By inserting key through face of grille.
    c. Operating mechanism not projecting through grille face.

9. Factory-fabricated multiple-blade extractors, furnished by grille manufacturer where shown.

    a. Multiple-blade extractors: Air-deflecting and air-straightening type with blades spaced two inches apart maximum.

10. For exhaust grilles, provide a single set of nonadjustable face bars or vanes having same appearance as supply grilles.

2.02 FINISHES:

A. Items exposed to public view in stations: Unless otherwise shown, factory-finished in baked enamel, colors as directed.

B. Items not exposed to public view: Factory-finished in light-gray baked enamel.

PART 3 – EXECUTION

3.01 INSTALLATION:

A. Install grilles and diffusers to permit key adjustment from face without other special tools.

B. Install vanes and volume-control dampers to permit removal through diffuser for access to duct.

END OF SECTION

SECTION 15865

FILTERS

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies providing air filters.

B. Related Work Specified Elsewhere:

1. Air Conditioning Units: Sections 15733A.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:

1. UL 900 Class 1.
2. ASHRAE: 52.1.

B. Source Quality Control:

1. Factory-tested or tested by an independent laboratory experienced in testing filters; certify compliance with requirements of ASHRAE Standard 52 for arrestance, efficiency, dust-holding capacity and pressure drop.

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.

PART 2 – PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. General Requirements:

1. In design of equipment, provide for interchangeability of items of equipment, subassemblies, and parts.

B. Throwaway (Replaceable) Prefilters:

1. Flat-panel filter units designed and fabricated for disposal when dust-load limit is reached.
2. Dry or adhesive-coated filter media, as standard with the manufacturer.
3. Maximum air flow through filters: Not exceeding manufacturer's published rated capacity but not exceeding 500 feet per minute at 0.10-inch w.g.
4. Designed to fit within space available and constructed so as to prevent passage of unfiltered air.

5. Filter frames constructed of 18-gauge galvanized steel with air-tight access panels for filter inspection, cleaning and replacement.
6. Filters are UL 900 Class I listed.

C. Controls:

1. Control panels factory wired.

a. Adjustable pressure-differential sensing device and wiring for remote surveillance.
b. Pressure range of 0.02-inch w.g. to 1.0-inch w.g. Accuracy of plus-or-minus 0.03-inch w.g.

PART 3 – EXECUTION

3.01 INSTALLATION:

A. Fit equipment and appurtenances within the space provided and make readily serviceable.

B. Examine each bag filter's media before installation for seepage and adhesive to surface of container.

C. Replace bag filters showing evidence of seepage.

D. After final testing and cleaning of fans and ductwork, replace prefilters and final filter media with new, clean media.

END OF SECTION

SECTION 15900A

HVAC INSTRUMENTATION AND CONTROLS

PART 1 – GENERAL

1.01 DESCRIPTION:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. See specification Section 15186 – Water Treatment System which is part of the Chiller Plant Monitoring System.

C. See specification section 15625 – Chillers: Status, Alarm and Control points described are part of the Chiller Plant Monitoring System.

D. Refrigerant Monitoring and exhaust system.

1.02 QUALITY ASSURANCE:

A. Provide a complete Chiller Plant Monitoring and Control System integrated with Water Treatment System – Monitoring as specified with all necessary hardware and software; programming, training, etc. in order to process the Sequence of Operation of Chiller Pant, Air-handling unit and Water Treatment Installation. Provide all necessary input and output points for a complete system operation. 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). 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):

1. Provide new AEMS sensor and controls for Refrigerant monitoring system. The input to the AEMS shall be from the Chiller plant monitoring panel (DDCP) system.
2. Provide new sensors for the Chillers, Chilled water and Condensing water pumps, Cooling Towers, Water Treatment System. The input to the AEMS shall be from the Chiller plant monitoring panel (DDCP) system.
3. The provision of sensors shall not be limited to items described in the above paragraphs, and shall be provided as required based on field verification and WMATA requirement.

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."

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.

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 Conditioning Unit or Fan Coil 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 Conditioning 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:

1) User Reports
2) Sequencing
3) Histories

3. Control panels for water treatment systems shall comply with the reference drawings shown as part of the contract drawings package.

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 ±0.36℉ between 32℉ and 100℉. Sensors shall be a Honeywell C7041C or approved equal. Sensor range shall be 0℉ to 100℉ and be f urnished 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 ± 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℉ to 110℉ 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℉ to 240℉.

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 ±0.1% of span, stability ±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 ± 0.5% of full scale.
2. Sensor shall be Honeywell P7640U or approved equal. Accuracy shall be ±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℉ to 122℉. 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℉ for supply air and 125℉ 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 were 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. 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.

K. Horn/ Strobe Combination:

1. Self-contained enclosure rated for indoor/ outdoor siren and strobe, with a sturdy aluminum back plate, polycarbonate housing, dual tamper protection.
2. 120 db sound output, ability to mount directly on the wall or 4” square back box, strobe color as required by owner.

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 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: 120Ohms
    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 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 Chiller Plant Room. Field verify exact conditions and provide a compatible system.

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.

3.04 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.

3.05 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. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest.
3. 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).

3.06 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.

3.07 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 air systems and water systems balancing, adjusting, and performance-testing of heating, exhaust, air-conditioning, and ventilating systems with ductwork, chillers, cooling towers and fan coil units.

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 water balance within six months prior to use on this project.

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:

a. Test and instrument location plans.
b. After initial balancing measurements, submit shop drawings for additional equipment such as pressure taps and balancing cocks necessary to effect proper water balance.

2. Certification:

a. Complete air and 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. Air balancing on exhaust air and air conditioning systems.
b. Collect data in accordance with referenced standards.
c. 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.

1) Air-conditioning units: Section 15733A

d. Air and Water-balance test reports to include data covering the following:

1) Air-conditioning units: Section 15733A
2) Chillers: Section 15625.

3) Cooling Towers: Section 15640.
4) Hydronic Pumps: Section 15185.
5) Fans: Section 15830
6) Control valves: Section 15900.

PART 2 – PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. Provide, as specified in Section 15205, additional equipment, such as balancing dampers, pressure taps, and balancing cocks necessary to effect proper air and water balance.

PART 3 – EXECUTION

3.01 BALANCING AND PERFORMING TESTING:

A. After completion of installation of heating, exhaust and air-conditioning systems, chillers, cooling towers, pumps, and prior to acceptance by the Engineer, adjust and balance air-handling systems, water systems, and appurtenances applicable to those systems to deliver the air and water quantities as specified and as shown. Make final tests after modifications are completed. Seal instrument test holes upon completion of balancing operation.

B. Air and Water balance:

1. Perform testing in accordance with referenced NEBB Standard, ASHRAE III 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 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.

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. Grounding electrode conductors:

      1) Insulated or bare conductor, as shown, in accordance with the following:

         a) Insulated conductor: As specified in Section 16120 for single-conductor cable.
         b) Bare conductor: Section 16120.

      2) Size:

         a) For use in ground grid and for connecting of ground grid to ground bus: 4/0 AWG.
         b) For connection of ground bus in train-control, communications, electrical, dispatcher, Bell system and mechanical rooms to main ground bus in ac-switchboard rooms: 2/0 AWG.
         c) For other grounding electrode conductors: In accordance with NEC Table 250-66.

   b. 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.

   c. Bonding conductor for stray current and cathodic protection and 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. Jumpers: Copper braided or leaf-type flexible jumper, size as necessary.
5. Exothermic welded electrical connections:

   a. Exothermic process using powdered metals contained in a mold to form a molecular bond between materials to be connected without application of an external source of heat or power in accordance with ANSI/IEEE 80-2000.

6. Molds, weld metal and associated accessories designed for making electrical connections between copper and copper, copper and steel, copper and cast iron and copper and ductile iron as required.

a. Welding system designed for making connections suitable for the application as follows:

1) Connections made outdoors for grounding using the standard process and not containing phosphorous or any caustic, toxic or explosive materials.
2) Connections made indoors or in confined spaces for grounding using a low-smoke, low-emission process.
3) Connections made specifically for cathodic protection applications using the standard process.

b. Molds made of graphite with permanent marking indicating name of manufacturer, model, conductor size, and type and size of welding mixture compatible with the welding process. Mold connection type suitable for making connections between various configurations of items as shown or specified.
c. Weld metal consisting of copper oxide and aluminum contained in a moisture-resistant container along with other necessary materials required for the specific application as determined by the manufacturer. Container for applications other than low-smoke, low-emission process to also include suitable starting material.
d. Container for weld metal identified with part number, type of metals to be connected and application such as standard outdoor, low emission or cathodic application.

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. Exothermically weld connections to ground rods in handholes, junction boxes and manholes, frame columns of bus passenger and bus supervisor shelters and station entrance pylon (type B) and light poles.
3. Splices in grounding conductor are prohibited.
4. 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 of Service Equipment:

1. Ground in accordance with NEC.
2. Ground enclosure and ground bus in switchgear, switchboard, motor-control center or panelboard to ground bus provided in substation or room using insulated grounding electrode conductor.
3. Install copper bonding jumper between neutral and ground bus as shown.

D. Grounding of Separately Derived AC System:

1. Ground in accordance with NEC.
2. Ground secondary neutral and enclosure of transformers to nearest ground bus or sub-bus using insulated grounding electrode conductor.
3. For transformer located outside of building, install additional grounding connector between transformer secondary neutral/enclosure and ground bus or grid using insulated grounding electrode conductor.

E. Grounding for Personnel Safety:

1. In substation, electrical and mechanical rooms, tie-breaker stations, chiller plants, fan shaft and pumping stations, bond exposed metallic structure, motor frame, ac-equipment enclosure, ductwork and metallic piping to local ground bus, using minimum of 6AWG insulated grounding conductor as follows:

   a. Ground multiple items of exposed metallic structure to local ground bus using a separate grounding conductor for each item or by using series-connected grounding conductors to connect two or more items.
   b. Ground each ac equipment enclosure to local ground bus using a separate grounding conductor.
   c. Connection of grounding conductor for ac equipment enclosure in series with grounding conductor for exposed metal structure is prohibited.

3.02 FIELD QUALITY CONTROL:

A. Test metallic conduits and raceways, metallic enclosures for equipment, metallic cable troughs, fences, metallic hand railings, metallic safety walk gratings, metallic structures, metallic covers, and junction boxes, for continuity to grounding system.

B. Conduct tests in presence of Engineer.

C. Inspect and test exothermic welds as follows:

1. Inspect finished exothermic welds for visual characteristics that are consistent with a properly made connection in accordance with the manufacturer's instructions and recommendations. Remove welds that do not meet minimum visual requirements as acknowledged by the Engineer, and reweld after cleaning the area to be welded.
2. Test mechanical strength of exothermic weld by applying three sharp blows to the weld with a two-pound hammer using 15-inch strokes. Acceptable welds to sustain the blows without cracking the weld metal or the bond between the two connecting materials. Remove defective welds and reweld after cleaning the area to be welded.

END OF SECTION

SECTION 16120

WIRE, CABLE AND BUSWAYS

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies providing wire, cable and busways.

B. Definitions:

1. Cable: Cable having low flammability and low smoke zero halogen generating characteristics.

C. Requirements for single-conductor cable and for multiple-conductor cable: Tested in accordance with the requirements of NFPA 130, 2014, Chapter 12.

D. Related Work Specified Elsewhere:

1. Wire connection accessories: Section 16125.
2. Raceways, boxes and cabinets: Section 16130.

1.02 QUALITY ASSURANCE:

A. Qualifications: Select a manufacturer who is engaged in production of similar wire, cable and busways.

B. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of the jurisdictional authorities.
2. National Electrical Code (NEC).
3. Insulated Cable Engineers Association (ICEA): S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, S-81-570.
4. IEEE: 1202-1991 IEEE Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies, 383-1974 IEEE Standard for Type Test of Class 1E Electrical Cables, Field Splices, and Connections for Nuclear Power Generating Stations.
5. National Electrical Manufacturers Association (NEMA): BU1, WC70, WC71, WC74.
6. American National Standards Institute (ANSI): C37.20.1, Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear; C37.20.2, Metal-Clad and Station-Type Cubicle Switchgear; C37.20.3, Metal-Enclosed Interrupter Switchgear; Z55.1, Gray Finishes for Industrial Apparatus and Equipment.
7. UL: 44, Rubber-Insulated Wires and Cables Thermoset-Insulated Wires and Cables; 62, Flexible Cord and Fixture Wire; 857, Electric Busways and Associated Fittings; and 1581, Standard for Electrical Wires, Cables, and Flexible Cords.
8. American Standards of Testing and Materials (ASTM): B3-95, Standard Specification for Soft or Annealed Copper Wire; B8-99, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft; D471-98e1, Standard Test Method for Rubber Property-Effect of Liquids, E662-97, Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials.
9. ITS: Directory of ITS Listed Products

C. Source Quality Control:

1. Cable and busways: Listed or labeled per UL or ITS directory.
2. Certified Test Reports from tests conducted in accordance with NFPA 130, 2014.

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. Samples:

a. Smoke-density test sample for jacket material: Specified sample will become property of the Authority.

3. Certification:

a. Certified flame-retardancy test reports (VW-1, IEEE 383, and IEEE 1202, Article 18) and data for tests performed not more than 12 months prior to submittal, for materials which are identical to those of cable furnished. Include test reports with submittal of shop drawings.
b. Submit smoke-density test reports and data for tests performed on the jacket material not more than 12 months prior to the submittal, for materials which are identical to those of the furnished cable. Include test reports with submittal of shop drawings.
c. Certified test reports demonstrating that cable complies with specified requirements and those of referenced ICEA Standards. Submit test reports prior to cable shipments.
d. Certificates from manufacturers verifying that products conform to specified requirements. Include certificate with submittal of shop drawings and with each cable shipment.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Mark each single-conductor cable, each multiple-conductor cable and each busway to show label per referenced UL or ITS 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

2.01 PRODUCTS AND MATERIALS:

A. General Requirements for Single-Conductor and Multiple-Conductor Cable:

1. Type and size: As shown.
2. Rated voltage: 600 volts.
3. Conductors:

a. ASTM B3 or B8 annealed copper.
b. Size 10 AWG and smaller: Solid or Class B or Class C stranded.
c. Size 8 AWG 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-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, S-81-570.
    b. Other cable: ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, S-81-570.

5. Non-metallic jacket for single-conductor cable and an overall covering on multiple-conductor cable:

    a. Chlorosulfonated polyethylene or cross-linked polyolefin.
    b. Cross-linked polyolefin complying with the following physical requirements. Properties tested in accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, and S-81-570 if ethylene-propylene-rubber (EPR) insulation is used, or with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692 if cross-linked polyethylene insulation is used. Jacket material free of PVC and PVC-based compounds.

        1) Tensile strength, minimum pounds per square inch: 1,800.
        2) Elongation at rupture, minimum percent: 150.
        3) Aging requirement: After 168 hours in air oven test at 100C, plus-or-minus one degree C:

            a) Tensile strength, minimum percentage of unaged value: 100.
            b) Elongation at rupture, minimum percentage of unaged value: 80.

        4) Oil immersion: 18 hours at 121C, plus-or-minus one degree C, ASTM D471, Table 1, No. 2 oil:

            a) Tensile strength, minimum percentage of unaged value: 80.
            b) Elongation at rupture, minimum percentage of unaged value: 80.

    c. Jacket materials other than cross-linked polyolefin complying with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692. Jacket material free of PVC and PVC-based compounds.

6. Flame retardancy: Single-conductor and multiple-conductor cable tested by independent agency demonstrating flame retardancy in accordance with the following:

    a. Single-conductor cable and individual conductors of multiple-conductor cable passing vertical wire (VW-1) flame test in accordance with UL1581 or ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692. Cable size for testing: 14AWG.
    b. Single-conductor cable, size 1/0 AWG and larger, passing vertical tray flame test, using ribbon gas burner in accordance with IEEE 1202 or IEEE 383. Cable size for testing: 1/0 AWG.
    c. Multiple conductor cable passing vertical tray flame test using ribbon gas burner in accordance with IEEE 383 or IEEE 1202. Cable size for testing: 7/C or 9/C with No. 12 AWG or No. 14 AWG conductors.

7. Smoke generation: Single and multiple-conductor cable jacket materials demonstrating low-smoke generation when tested in accordance with ASTM E662 by independent, nationally recognized testing agency.

    a. Conduct tests on specimens of overall jacket material for multiple-conductor cable and of jacket material for single-conductor cable.

b. Prepare slab specimens for each material .100 inch, plus-or-minus .005-inch thick, identical to those of finished cables and meeting minimum physical requirements specified.

1) Prior to testing, submit six-inch square portion of each specimen. Tag sample with manufacturer's jacket or insulation identification code or number.

c. Test values for chlorosulfonated polyethylene not to exceed the following:

1) Flaming mode:

a) Uncorrected maximum specific optical density during first four minutes of test: 325.
b) Uncorrected maximum specific optical density for entire 20-minute test: 400.

2) Nonflaming mode:

a) Uncorrected maximum specific optical density during first four minutes of test: 325.
b) Uncorrected maximum specific optical density for entire 20-minute test: 480.

d. Test values for cross-linked polyolefin not to exceed the following:

1) Flaming mode:

a) Uncorrected maximum specific optical density during first four minutes of test: 150.
b) Uncorrected maximum specific optical density for entire 20-minute test: 300.

2) Nonflaming mode:

a) Uncorrected maximum specific optical density during first four minutes of test: 150.
b) Uncorrected maximum specific optical density for entire 20-minute test: 300.

8. Applied voltage testing:

a. Single-conductor cable and individual conductors of multiple-conductor cable to be given applied ac voltage dielectric-strength test, i.e., six-hour water-immersion test.
b. For single conductors of multiple-conductor cable, conduct tests prior to assembly as multiple-conductor cable.
c. Test procedures:

1) Polyethylene-insulated conductors: In accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692.
2) Other conductors: In accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, and S-81-570.

B. Single-Conductor Cable:

1. Insulated with ethylene-propylene-rubber with non-metallic jacket as specified. UL-Labeled as Type RHW-2.
2. Color coding: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.

C. Multiple-Conductor Cable:

1. Individual conductors:

a. Number of conductors: As shown.
b. Construction: Complying with one of the following:

1) Insulated with ethylene-propylene-rubber, with or without non-metallic jacket.
2) Insulated with composite compound of ethylene-propylene-rubber and polyethylene, without outer jacket.
3) Insulated with filled cross-linked polyethylene without jacket.

c. Phase and neutral conductors: Individually insulated.
d. Neutral conductors: Same size as phase conductors.
e. Bare ground conductors: Sized in accordance with the NEC, unless otherwise shown.
f. UL Listed as Type RHW-2 or XHHW-2.

2. Conductors assembled with nonwicking, flame-retardant filler to form cable of circular cross section.
3. Metallic sheath:

a. Provide one of the following:

1) Size 1 AWG and larger:

a) Interlocked aluminum-tape armor.
b) Continuous corrugated aluminum sheath conforming to ICEA S-19-81, Table 4-26A.

2) Size 2 AWG and smaller: As specified for 1 AWG and larger or continuous smooth aluminum sheath conforming to ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692.

b. Metallic covering not required for multiple-conductor TC cable with overall non-metallic jacket when installed in cable tray.

4. Multiple-conductor cable provided with overall non-metallic jacket as specified.
5. Cable UL-listed as follows:

a. Non-metallic-sheathed cable: Type TC, suitable for wet and dry locations.
b. Metallic-sheathed cable: Type MC, suitable for wet and dry locations.

6. Color coding:

a. Power cables: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.
b. Control cables: In accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692.

D. Fixture Wire: UL 62, with the following additional requirements:

1. Type: SF-2 silicone-rubber insulated or as necessary to suit temperature rating of lighting fixture, minimum 90C.
2. Conductor: Stranded copper conductor 16AWG or larger as shown.

E. Bare Conductors: ASTM B3 or B8, annealed copper conductor; 8AWG and larger, Class B stranded, unless otherwise shown or specified.

PART 3 – EXECUTION

3.01 INSTALLATION:

A. Install type cable as specified.

B. Install single-conductor cable in conduit, underfloor duct or wireway. Install UL Type TC multiple-conductor cable in cable trays only. Install UL Type MC multiple-conductor cable and ground cable on channel inserts, cable trays, racks, trench or trough using straps and fasteners as specified in Section 16130. Install UL Type MC multiple-conductor cable in conduit where shown or required. On walls or ceilings, fasten cable and bus duct directly to channel inserts, or use expansion-bolt anchors to attach to concrete and toggle bolts to attach to concrete masonry unit walls. Splice cable only when unavoidable.

C. Install motor feeders, service connections and extensions in accordance with reference codes. Install motor feeder in 18-inch minimum length liquid-tight flexible conduit at motor conduit box.

D. Use nylon straps to bundle and secure wire and cable located in panelboards, cabinets, switchboards, motor control centers and switchgear.

E. Minimum bending radius 12 times outer diameter of cable. Where shown, use shorter bending radius as permitted by NEC, ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692, and cable manufacturer.

F. To facilitate pulling cable, use listed per UL or ITS directory lubricant recommended by cable manufacturer.

G. In damp and dusty indoor locations, tunnel areas, manholes and outdoor locations, seal cable at conduit termination using duct-sealing compound.

H. Where shown or necessary, install cable-seal fitting specified in Section 16130 to prevent entry of water into electrical facilities. Where approved, use seal compound specified in Section 16130.

3.02 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 shown.

3.03 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 Engineer.

B. Submit test procedure for approval and perform approved tests including, but not limited to, the following:

1. Single-conductor cable and multiple-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

1.01 DESCRIPTION:

A. This section specifies providing wire-connection accessories, such as connectors, terminal lugs and fittings, bundling straps, insulating tape and resin.

1.02 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. National Electrical Code (NEC).
3. UL: 486A, Wire Connectors and Soldering Lugs for Use With Copper Conductors.
4. American Standards of Testing and Materials (ASTM): D149-97a, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies; D257-99, Standard Test Methods for DC Resistance or Conductance of Insulating Materials; D412-98a, Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension; D570-98, Standard Test Method for Water Absorption of Plastics; D638-00, Standard Test Method for Tensile Properties of Plastic; D696-98, Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30°C and 30°C with a Vitreous Silica Dilatometer; D792-00, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement; D1000-99, Standard Test Method for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications; D1518-85(1998)e1, Standard Test Method for Thermal Transmittance of Textile Materials; D5034-95, Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test); D5035-95, Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method); D2240-00, Standard Test Method for Rubber Property-Durometer Hardness; and G21-96, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
5. American National Standards Institute (ANSI): C119.1, Sealed Insulated Underground Connector System 600V
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.

1.03 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.

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 in shipment and to avoid damage.

C. Store products in secure and dry storage facility.

PART 2 – PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. Connectors, Terminal Lugs and Fittings:

1. In accordance with UL 486A.
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.
4. For 250 Kcmil and larger conductor cable: Long-barrel, double-compression tin-plated copper connectors and terminal lugs with two-hole pad.
5. For multiple-conductor cable: Watertight aluminum fittings with stainless-steel pressure ring and set screws or compression cone for grounding of aluminum sheath of MC cable.

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.
2. For outdoor use: Ultraviolet-resistant.

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 D1000-99:

   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 D1000-99:

   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.

3. Arcproof tape: Flexible, coated one side with flame-retardant flexible elastomer, self-extinguishing, non-combustible, with the following minimum properties:

    a. Thickness, ASTM D1000: 30 mils.
    b. Breaking strength, ASTM D5034-95 and D5035-95: 50 pounds per inch width.
    c. Thermal conductivity, ASTM D1518-85: 0.0478 BTU per hour per square foot per degree F.
    d. Electrical arc resistance: Withstand 200 amperes arc for 30 seconds.

4. Glass tape: Woven-glass fabric tape with pressure-sensitive thermosetting adhesive, with the following minimum properties when tested in accordance with ASTM D1000-99:

    a. Nominal width: 3/4 inch.
    b. Thickness: Seven mils.
    c. Breaking strength: 170 pounds per inch width.
    d. Elongation: Five percent.
    e. Dielectric breakdown: 2,500 volts.
    f. Insulation resistance, indirect method of electrolytic corrosion: 5,000 megohms.

D. Epoxy Resin: Suitable for insulating and moisture sealing cable splices, with the following minimum properties:

1. Dielectric strength, ASTM D149-97a: 400 volts per mil.
2. Volume resistance, ASTM D257-99: 2.8×10^{15} ohm per centimeter cube at 30C.
3. Water absorption, ASTM D570-98:

    a. 0.193 percent in 24 hours at 23C.
    b. 0.62 percent in 24 hours at 53C.

4. Tensile strength, ASTM D638-00: 8,000 psi.
5. Elongation, ASTM D638-00: 2.4 percent.
6. Coefficient of expansion, ASTM D696-98: 6.8 X 10-5 inch per inch per degree C.

E. Cable splice and tap-insulation/sealing kit: Suitable for use on 600-volt, 90C cables, material compatible with cable insulation and jacket, meeting the seal test requirements of ANSI C119.1.

1. Heat-shrinkable tubing or wraparound heat-shrinkable sleeve: approved per referenced UL or ITS directory, flame-retardant, corrosion-resistant thick-wall tubing with factory-applied sealant for field insulation on in-line splices and taps or wraparound-type sleeve for retrofit installation on existing splices and taps to provide a watertight seal and insulating encapsulation, with the following additional requirements:

    a. Material: Cross-linked polyolefin.
    b. Shrink ratio: 3 to 1 minimum.
    c. Physical properties:

        1) Ultimate tensile strength: 2,350 psi, ASTM D412-98a.
        2) Ultimate elongation: 350 percent, ASTM D412-98a.
        3) Hardness, Shore D: 42, ASTM D2240-00.
        4) Water absorption: 0.050 percent, ASTM D570-98, Method 6.1.
        5) Specific gravity: 1.28, ASTM D792-00.

    d. Electrical properties:

        1) Dielectric strength: 450 volts per mil, ASTM D412-98a.

2) Volume resistivity: 1 x $10^{14\ ohm}$ cm, ASTM D257-99.

e. Thermal properties:

1) Continuous operating temp.: -55C to +135C.
2) Air oven aging (14 days at 175C):

a) Tensile strength: 2,680 psi.
b) Elongation: 375 percent.

3) Low temp. flexibility (4 hours at -55C): No cracking when flexed.
4) Heat shock (4 hours at 250C): No cracking, flowing or dripping.

f. Chemical properties:

1) Corrosivity: Non-corrosive.
2) Fungus resistance: Non-nutrient, ASTM G21-96.
3) Flammability: Self-extinguishing.

PART 3 – EXECUTION

3.01 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.

F. Wrap ½-lapped layer of arcproof tape, glass tape overall on cable splices installed in air tunnels, ducts and shafts.

G. Install terminal fittings on multiple-conductor cable in accordance with manufacturer's recommendation. Completely seal cable from moisture.

3.02 INSPECTION:

A. Have splices and taps in junction and pull boxes inspected by the Engineer or the manufacturer's representative, when available.

END OF SECTION

SECTION 16130

RACEWAYS, BOXES AND CABINETS

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies providing conduit, raceways, cable trays, boxes and cabinets to form raceway and support system for power, communication and control cables.

B. Related Work Specified Elsewhere:

1. Grounding and bonding: Section 16060.
2. Firestopping: Section 07841.

1.02 QUALITY ASSURANCE:

A. Qualifications: Select a manufacturer who is engaged in production of similar raceways, boxes and cabinets.

B. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of the jurisdictional authorities.
2. National Electrical Code (NEC).
3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum); VE 1, Metallic Cable Tray Systems; TC-2, Electrical Polyvinyl Cloride (PVC) Tubing and Conduit.
4. American National Standards Institute (ANSI): C80.1, Rigid Steel Conduit - Zinc Coated; C80.5, Aluminum Rigid Conduit - (ARC); and Z55.1, Gray Finishes for Industrial Apparatus and Equipment.
5. UL: 5, Surface Metal Raceways and Fittings; 6, Rigid Metal Conduit; 50, Enclosures for Electrical Equipment; 94, Test for Flammability of Plastic Materials for Parts in Devices and Applicances; 360, Liquid Tight Flexible Steel Conduit; 514A, Metallic Outlet Boxes; 514B, Fittings for Conduit and Outlet Boxes; 514C, Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers; 651, Schedule 40 and 80 Rigid PVC Conduit; 884, Underfloor Raceways and Fittings; and 1684, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
6. Federal Specifications (FS): FF-S-325C, FF-S-760, TT-S-227.
7. American Standards of Testing and Materials (ASTM): A47/A47M-99, Standard Specification for Ferritic Malleable Iron Castings; A123/A123M-00, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; A185-97, Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement; A276-00a, Standard Specification for Stainless Steel Bars and Shapes; A507-00, Standard Specification for Drawing Alloy Steel, Sheet and Strip, Hot-Rolled and Cold-Rolled; A532/A532M-93a(1999)e1, Standard Specification for Abrasion-Resistant Cast Irons; A536-84(1999)e1, Standard Specification for Ductile Iron Castings; A615/A615M-00, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement; A653/A653M-00, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; B138-96, Standard Specification for Manganese Bronze Rod, Bar and Shapes; B455-96, Standard Specification for Copper-Zinc-Lead Alloy (Leaded-Brass) Extruded Shapes; B584-00, Standard Specification for Copper Alloy Sand Castings for General Applications; B633-98, Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel;

C109/C109M-99, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens); C173-94ae1, Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method; C231-97e1, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method; D149-97a, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies; D495-99, Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation; D570-98, Standard Test Method for Water Absorption of Plastics; D638-00, Standard Test Method for Tensile Properties of Plastics; D648-00a, Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position; and D790-00, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

8. American Association of State Highway and Transportation Officials (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.
3. Cabinets.

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.

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 in shipment and to avoid damage or distortion.

C. Store products in secure and dry storage facility.

PART 2 – PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. General Requirements for Conduit, Raceways, Cable Trays, Boxes, Cabinets and Fittings:

1. Size: As shown, minimum conduit size 3/4 inch.
2. Materials:

a. Steel sheet: ASTM A507-00.
b. Zinc-coated steel sheet: ASTM A653/A653M-00.
c. Cast iron: ASTM A532/532M-93a(1999)e1.
d. Ductile iron: ASTM A536-84(1999)e1.
e. Malleable iron: ASTM A47/A47M-99.
f. Bronze extrusion: ASTM B455-96, Alloy C38500.

g. Bronze casting: ASTM B584-00, Alloy C83600.
h. Rigid fiberglass reinforced epoxy: UL 1684.
i. Stainless steel: ASTM A276-00a, Type 304.

3. Zinc coating:

a. Hot-dip galvanizing: ASTM A123/A123M-00.
b. Electro galvanizing: ASTM B633-98.

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.
4. Sizes 1-1/2 inch and above provided with separate grounding conductor.

D. Conduit Expansion Fittings and Expansion and Deflection Fittings:

1. Materials:

a. For galvanized-steel rigid conduit:

1) Expansion fittings: Steel or malleable iron, hot-dip galvanized.
2) Expansion/deflection fittings: Bronze or ductile iron end couplings, neoprene sleeve and stainless steel clamping bands.

2. Conduit expansion fitting: Weatherproof.
3. Conduit expansion and deflection fitting: Watertight.
4. 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, cabinets, boxes and gutters in electrical rooms and aboveground indoor locations: Threaded nylon-insulated bushing and locknuts.
3. For enclosure, cabinets, boxes and gutters with hub in outdoor, tunnel and underground locations, except electrical rooms: Threaded watertight hub fitting with gasket.
4. For enclosure having punched or formed knockout for conduit entry in outdoor and underground locations, except electrical rooms: Threaded watertight fitting with gasket, nylon-insulated throat and sealing locknut.

F. Conduit and Cable-Seal Fittings:

1. Conduit seal:

a. To provide watertight seal between concrete and conduit where it penetrates wall, floor or ceiling.
b. Size as shown or necessary.
c. Materials: Body and pressure clamp of malleable or cast iron with a neoprene sealing grommet and PVC-coated or galvanized-steel pressure rings, oversized sleeve of FRE or galvanized steel.

d. Seal between conduit and concrete to withstand pressure from 50-foot head of water without leakage.

2. Cable seal:

a. To provide watertight seal between cable and conduit for use with single-conductor or multiple-conductor cable as necessary.
b. Size as necessary, drilled to accommodate cable.
c. Pressure discs of PVC-coated steel and sealing ring of neoprene.
d. Seal between cable and conduit to withstand water pressure of 50 psi without leakage.

3. Seal compound:

a. FS TT-S-227, two-component, fast-setting, polymeric sealing compound to provide watertight seal between concrete and conduit, between cable and conduit.
b. Pour-type for horizontal and gun-grade for vertical or overhead application.
c. When cured, sealant to have rubber-like flexibility allowing minimum movement of conduit and cable in temperature range of minus 40F to plus 150F without loss of watertight seal.
d. Pot life: 15 minutes.
e. Minimum ambient temperature for application: 35F.
f. Initial cure: 15 minutes.
g. Final cure: Seven days.
h. Hardness, Durometer A: 20-35.
i. Seal between conduit and concrete to withstand pressure from 50-foot head of water without leakage.
j. Seal between conduit and single-conductor or multiple-conductor cable to withstand water pressure of 70 psi without leakage.
k. Fox Industries, Type FX-571G or approved equal.

G. 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, Type 304, or approved equal.
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: Stainless steel, Type 304, or approved equal.

2. Multiple pipe hangers (trapeze-type): Consisting of two or more hanger rods, horizontal member, U-bolt clamp and other attachment necessary for securing hanger rods and conduit, with the following additional requirements:

a. Material and finish: Stainless steel, Type 304, or approved equal.
b. Hanger rod: Not smaller than 3/8-inch diameter, threaded for sufficient distance at each end to permit at least 1-1/2 inches of adjustment.
c. Horizontal member: Channel, 1-1/2 inches square or 1-5/8 inches square by 12 gauge or heavier. Weld two or more channels together for greater strength if necessary.
d. Design: Capable of supporting load equal to sum of weights of conduit, cable and hanger plus 200 pounds. At design load, stress at root of thread on hanger rod 9,500-psi maximum; stress in horizontal member 12,500-psi maximum.

H. Boxes and Cabinets:

1. Outlet boxes:

a. UL 514A, capable of accommodating conduit as shown.
b. Material and finish:

1) Steel, malleable iron, cast iron or ductile iron.
2) Hot-dip galvanized or electro galvanized after fabrication.

c. For aboveground indoor locations and electrical rooms: Punched or formed knockouts.
d. For wall receptacles and switches, single or double devices: Outlet boxes 4-11/16 inch square by 1-1/2 inch deep.
e. For recessed wall-mounted receptacles: Watertight cast-iron outlet box, three-inch diameter, of suitable depth and complete with the following:

1) Bronze faceplate with flush-mounted screw plug, without exposed fasteners, M32 finish.
2) Screw plug attached to outlet-box assembly by chain or other approved means, M32 finish.
3) Bronze faceplate flange, five inches in diameter, extending beyond box, M32 finish.
4) One special screw-plug removal tool with every 10 receptacles.

2. 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) Steel, malleable iron, cast iron or ductile iron.
b) Hot-dip galvanized or electro galvanized after fabrication.
c) Stainless steel in tunnel areas.

2) Non-metallic boxes:

I. Expansion Bolt Anchors: FS FF-S-325C Group II, stainless steel, Type 304, or approved equal.

PART 3 – EXECUTION

3.01 INSTALLATION:

A. General:

1. Use size, type, general routing, location of conduit, raceways, boxes and cabinets as shown and specified.
2. Install metallic raceway, fittings, boxes and cabinets free from contact with reinforcing steel.
3. Where aluminum is placed in contact with dissimilar metal or with concrete, separate contact surfaces by means of gasket, nonabsorptive tape or coating to prevent corrosion.
4. Make metallic conduit, raceways, ducts and cable trays, 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. Traction-power substations, tie-breaker stations, ac-switchboard, electrical, train-control, communication and mechanical rooms: Where shown or where necessary to prevent seepage of subsoil or water into such areas, seal where conduits in contact with concrete and seal cable inside conduit using cable seal or sealing compound in accordance with the following requirements:

    a. Where shown and as necessary, install cable seal and conduit seal in accordance with the manufacturer's recommendations.
    b. Use sealing compound where approved and in accordance with manufacturer's recommendations, with the following additional requirements:

        1) Before applying sealing compound, prime concrete, conduit and cable surface using primer recommended by manufacturer.
        2) Pour or inject compound to prevent voids inside seal and to keep cable centered in conduit.

    c. In empty conduit installed for future use, install blank cable seal inside conduit to prevent seepage of water.
    d. All conduits free of water before conduit seals are installed.

4. Apply lead-free conductive anti-seize compound to threaded-conduit joints.
5. In outdoor and underground locations, except electrical rooms, use threaded-conduit hub to attach conduit to equipment enclosure. Use watertight conduit fitting with gasket, nylon-insulated throat and sealing locknuts for attachment of conduit to enclosure having punched or formed knockout.
6. In aboveground indoor locations and electrical rooms, use locknut and nylon-insulated bushing to attach conduit to enclosure.
7. Install suitable caps or plugs in empty conduit for future extension. Leave approved nylon or polyester pull line in each conduit.
8. Thread and ream ends of field-cut conduit to remove rough edges. Use bushing at conduit entrance to boxes, cabinets and equipment enclosures.
9. Bends:

    a. Unless otherwise shown or specified, install conduit bends in accordance with reference codes.
    b. Install bends in buried conduit in accordance with the following:

Size of Conduit (in inches)	Minimum Radius of Factory-Bend (in inches)	Minimum Radius of Field-Bend (in inches)
3	18	24
4	24	30
5	48	48
6	48	48

    c. Bend conduit so that field-made bend is free from cuts, dents and other surface damage.

10. Support conduit during construction to prevent distortion and to ensure independent support.
11. Support horizontal conduit with one-hole pipe straps or individual pipe hangers.
12. Secure conduit supported on multiple-hangers (trapeze) or channel inserts by fasteners suitable for such purpose.
13. Where conduit is attached to masonry surface, use malleable-iron spacers with Style A pipe straps.
14. Support and secure vertical conduit spanning open areas at intervals not exceeding 10 feet.
15. Support conduit above suspended ceiling using applicable specified methods.
16. Install conduit so as to drain moisture to nearest outlet or pull box.
17. Use minimum of 18-inch long liquid-tight flexible-conduit connection for equipment enclosure subject to vibration.
18. Do not use wire for support of conduit and cable.
19. Install expansion fitting in exposed conduit runs longer than 300 feet and where shown. Install expansion/deflection fittings where embedded conduits cross structural expansion joints. Where embedded conduits cross a structural contraction joint, paint the external surface of conduit with linseed oil or other compatible bond breaker for two feet on each side of contraction joint.

C. Surface Raceways:

1. Install as shown.

D. Outlet, Junction and Pull Boxes:

1. Mount outlet boxes as shown.
2. Arrange front of box or attached plaster cover flush with finished wall or ceiling.
3. Keep number of knock-outs to minimum.
4. Clean boxes thoroughly after installation and correct damage to boxes and to finish.
5. Install covers on boxes mounted on walls and ceilings.
6. Measure height of wall-mounted outlet box from finished floor to horizontal centerline of cover plate.
7. Fasten floor boxes securely in place.
8. Install junction and pull boxes so that covers are readily accessible.
9. Do not install boxes above suspended ceilings except where ceilings are removable or definite provision is made for access to boxes.

E. Cabinets:

1. Fasten cabinet securely using expansion bolts, toggle bolts or mounting ears.
2. Touch-up damaged painted finish.

F. Use expansion-bolt anchors to secure equipment to concrete surfaces.

3.02 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 in accordance with Section 07481.

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 in accordance with Section 07841.

C. Close unused openings or spaces in floors, walls and ceilings. Plug or cap unused conduit and sleeves.

3.03 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 designations shown. Where conduits are terminated flush with concrete structure, install three-ply laminated phenolic plate, engraved through black face to white core and attached adjacent to conduits' entrance by means of non-metallic screws. Engrave conduits' designations within circles arranged in pattern similar to that of conduits.

3.04 FIELD QUALITY CONTROL:

A. Arrange with the Engineer for inspection and approval of embedded conduit and boxes prior to concrete placement.

B. Arrange with the Engineer for inspection by electrical utility company representative of incoming-service conduit prior to placing concrete.

C. Test metallic conduit and boxes for electrical continuity. Conduct tests in presence of Engineer.

D. Test not less than 0.5 percent of total installed channel inserts and spot inserts as directed for compliance with specified pullout-load rating. Replace and retest inserts which fail. Conduct tests in presence of Engineer.

E. Arrange with the Engineer for inspection and approval of direct-buried conduits for future train control circuits prior to backfilling.

END OF SECTION

SECTION 16145

WIRING AND CONTROL DEVICES

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies providing switches, cover plates, limit switches, occupancy sensors, receptacles, plugs, magnetic contactors, automatic transfer switches, photoelectric controls and time switches.

B. Related Work Specified Elsewhere:

1. Wire connection accessories: Section 16125.
2. Grounding and bonding: Section 16060.
3. Raceways, boxes and cabinets: Section 16130.

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. National Electrical Manufacturers Association (NEMA):WD1, General Color Requirements for Wiring Devices*;* KS1, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum); ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC; ICS 12, Profiles of Networked Industrial Devices--Part 1: General Rules; NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
4. American National Standards Institute (ANSI): Z55.1, Gray Finishes for Industrial Apparatus and Equipment.
5. UL: 98, Enclosed and Dead-Front Switches; 198D, Class K Fuses; 198E, Class R Fuses; 508, Industrial Control Equipment; 773, Plug-In Locking-Type Photocontrols for Use with Area Lighting; 1008, Transfer Switch Equipment.
6. American Standards of Testing and Materials (ASTM): A47/A47M-99, Standard Specification for Ferritic Malleable Iron Castings; A276-00a, Standard Specification for Stainless Steel Bars and Shapes; and A507-00, Standard Specification for Drawing Alloy Steel, Sheet and Strip, Hot-Rolled and Cold-Rolled.
7. ITS: Directory of ITS Listed Products

B. Source Quality Control:

1. Following items listed per referenced UL or ITS directory:

a. Snap switches.
b. Disconnect switches.
c. Receptacles and plugs.

C. Qualifications: Select a manufacturer who is regularly engaged in the production of automatic transfer switches.

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 of factory tests performed on each automatic transfer-switch unit in accordance with reference standards.
   b. Furnish certificate from manufacturer verifying that automatic transfer switches conform to specified requirements. Include certificate with submittal of shop drawings.

3. Documentation for Automatic Transfer Switch:

   a. Submit field test plan within 60 days after award with accompanying documentation in the form of test data recording sheets and list of proposed test equipment for approval prior to testing.
   b. Submit certified copies of test data, dated and clearly identified within two weeks after completion of testing.

4. Operation and Maintenance Manuals for Automatic Transfer Switch.

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 products in secure and dry storage facility.

PART 2 – PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. Snap Switches:

1. NEMA WD1, specification grade.
2. Rating:

   a. Twenty amperes at 120-277 volts ac.
   b. Horsepower-rated when used as disconnecting device for motor circuit.

3. Body and base: Fully enclosed, brown, fire-resistant, non-absorptive thermosetting urea or nylon.
4. Contacts: Silver alloy.
5. Mounting yoke: Corrosion-resistant metal with plaster ears.
6. Poles: Single-pole, double-pole, three-way or four-way as shown.

B. Disconnect (Safety) Switches:

1. UL 98, NEMA KS1, heavy-duty, fusible or non-fusible as shown.
2. Voltage rating: 240 volts ac, 480 volts ac or 250 volts dc as shown and as necessary.
3. Number of poles and current rating: As shown and as necessary.

4. Fuses:

   a. UL 198D.
   b. For fused disconnect switch associated with motor load: UL Class RK5 with time delay or as shown.
   c. For fused disconnect switch associated with other loads: UL Class RK1 or as shown.
   d. Current rating: As shown.

5. Enclosure: (NEMA 250)

   a. Type:

      1) For aboveground indoor locations and electrical rooms: Type 1.
      2) For tunnel and underground locations, except electrical rooms: Type 4.
      3) For outdoor locations: Type 3R.

   b. Materials:

      1) Steel sheet: ASTM A507-00.
      2) Malleable iron: ASTM A47/A47M-99.

   c. Finish: Metallic surface cleaned, degreased, primed with zinc primer and finished with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.

6. Quick-make/quick-break switching mechanism with operating handle external to enclosure with positions labeled ON/OFF and capable of being padlocked in OFF position, defeatable interlock to prevent opening of enclosure door when switch is closed.

C. Cover Plates:

1. Wall plates:

   a. NEMA WD1, suitable for specified receptacles and switches, size suitable for recess-mounted or surface-mounted associated outlet box, stainless steel, ASTM A276-00a, Type 304, or approved equal.
   b. For use in indoor public areas: Bronze, with M32 medium satin finish as specified in Section 05700.
   c. For above ground indoor service areas and electrical rooms: Steel, stainless steel or aluminum plate, as standard with the manufacturer.

PART 3 – EXECUTION

3.01 INSTALLATION:

A. Install switches as shown and in accordance with referenced codes and standards in Article 1.2, and manufacturer's instructions.

B. Install cover plate on switch and receptacle.

C. Ground Disconnect switches and snap switches in accordance with Section 16060.

D. Make power cable connections to snap switches 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.

E. Make power cable connections to snap switches using their side screw wiring connection terminals.

F. Apply matching touch-up paint as necessary.

3.02 FIELD QUALITY CONTROL:

A. Furnish necessary test equipment and perform the following in the presence of the Engineer, in accordance with approved procedures:

1. Test equipment enclosure for continuity to grounding system.
2. Check tightness of cable connections of snap switches and disconnect switches.
3. Test operations of circuits and controls of switches.

B. Submit certified test reports for compliance with field quality control requirements.

END OF SECTION

SECTION 16225

MOTORS

PART 1 – GENERAL

1.01 DESCRIPTIONS:

A. This section specifies providing motors.

B. Related Work Specified Elsewhere:

a. Grounding and bonding: Section 16060.
b. Wire connection accessories: Section 16125.
c. Raceways, boxes and cabinets: Section 16130.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:

a. Comply with codes and regulations of jurisdictional authorities.
b. NEC.
c. IEEE: 85, 112.
d. NEMA: MG1.
e. ANSI: Z55.1.
f. ASTM: A582.
g. OSHA: 1910.95.

1.03 SUBMITTALS:

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

a. Shop Drawings:
b. Outline dimensions.
c. Cross section showing internal construction and weight.
d. Connection diagram.
e. Certification.
f. Operation and Maintenance Manuals.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Ship each motor securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.

B. Store motors in secure and dry storage facility.

PART 2 – PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. Motors:

a. NEMA MG1, squirrel-cage, induction-type, unless otherwise shown.
b. Rating:
c. Horsepower: As shown.
d. Voltage and frequency:

    1) Motors, 1/2 HP and smaller: 115-volt, single-phase, 60 Hertz.
    2) Above 1/2 HP: 460-volt, three-phase, 60 Hertz, unless otherwise specified or shown.
    3) For motors in air-conditioning units:

        a) For units up to and including 10,000 BTUH: 115-volt, single-phase, 60 Hertz.
        b) For units from over 10,000 BTUH up to and including 36,000 BTUH: 208-volt, single-phase, 60 Hertz.
        c) For units over 36,000 BTUH: 460-volt, three-phase, 60 Hertz.

e. RPM: As shown.
f. Time rating: Continuous, unless otherwise shown.
g. Nominal full-load efficiency: Premium Efficency when tested in accordance with NEMA MG1 and IEEE 112.
h. Design:
i. Single-phase motors: Design N, suitable for full-voltage across-the-line starting.
j. Three-phase motors: Design B, unless otherwise shown, with the following additional requirements:

    1) Up to and including 50-HP motors: Suitable for full-voltage across-the-line starting.
    2) Above 50-HP motors: Suitable for reduced-voltage starting.

k. Service factor:
l. Motors, one HP and smaller: In accordance with NEMA MG1.
m. Above one-HP up to and including 200-HP motors: 1.15.
n. Above 200-HP motors: 1.00.
o. Insulation: Class and allowable temperature rise above average ambient temperature of 30C and maximum ambient temperature of 40C as follows:
p. Integral-horsepower motors:

    1) Dripproof motors: Class B insulation with Class B temperature rise.
    2) Totally enclosed motors: Class F insulation with Class B temperature rise, unless otherwise shown or specified.

q. Fractional-horsepower motors: In accordance with NEMA MG1.
r. Noise level: NEMA MG1-12.49 but not to exceed requirements of OSHA 1910.95 when measured in accordance with IEEE 85.
s. Enclosure:
t. Dripproof, fully guarded; totally enclosed fan-cooled guarded; or totally enclosed air-over as specified.
u. Heavy-duty steel or cast-iron frame.
v. End bell:

    1) Up to 10HP: With cast-iron or aluminum end bells.
    2) 10HP and above: With cast-iron end bells.

w. Mounting: Foot-mounted on pad or adjustable pad, if necessary or as otherwise shown.
x. Provision for grounding.
y. Finish: Red-oxide zinc-chromate primer with finish coat of light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.

z. Totally enclosed air-over:

1) Variation to totally enclosed fan-cooled machines with air flow for cooling supplied by fan specified elsewhere.
2) Fan/motor application factory-engineered for air flow shown or specified.

aa. Conduit box:
bb. Diagonally split, suitably gasketed.
cc. Type:

a) Up to 10HP: Steel, cast iron or aluminum with threaded or punched conduit holes.

2) 10HP and above: Cast iron with threaded conduit holes.

dd. Size suitable to accommodate motor and line leads including taping.
ee. Capable of rotation in each 90-degree position.
ff. Bearings:
gg. Unless otherwise specified, average life 15 years, but not less than three years at continuous operation, with double shields.
hh. Integral-horsepower motors:

1) Five HP and smaller: Sealed ball bearings or roller bearings.
2) Above five HP: Ball bearings or roller bearings with grease fittings and pressure-relief fittings for in-service lubrication.

ii. Fractional-horsepower motors:

1) 1/6 HP and larger: Sealed ball bearings.
2) Below 1/6 HP: Sealed ball bearings or sleeve.

jj. Motors for hermetically sealed and semi-hermetically sealed compressors: NEMA MG1, 18.076 through 18.093.
kk. Motors for close-coupled pumps: Stainless-steel shaft in accordance with ASTM A582, Type 303.
ll. Provide nameplate on each motor in accordance with NEMA MG1-10.37.

PART 3 – EXECUTION

3.01 INSTALLATION:

A. Install motors where shown and in accordance with the NEC.

B. Install conduit in accordance with Section 16130.

C. Connect power cable as shown and in accordance with Section 16125.

D. Ground motor enclosure in accordance with Section 16060.

3.02 FIELD QUALITY CONTROL:

A. Furnish necessary equipment and perform the following tests:

a. Check and test wiring connections in accordance with wiring diagram.
b. Test to ensure that insulation resistance of motor winding is 10 megaohms minimum.

c. Test motor enclosure for continuity to grounding system.
d. Test motors for proper operation with their associated controls.

B. Submit certified test reports.

END OF SECTION

SECTION 16270

TRANSFORMERS

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies providing transformers and automatic voltage regulators.

B. Related Work Specified Elsewhere:

1. Wire connection accessories: Section 16125
2. Grounding and bonding: Section 16060.

C. Design Criteria:

1. Floor loading: Transformer base compatible with floor design-loading of 250 pounds per square foot.

1.02 QUALITY ASSURANCE:

A. Qualifications: Select a manufacturer who is regularly engaged in the repetitive production of transformers and automatic voltage regulators of the types and ratings described in these specifications using the latest technology and who has a proven record of successful manufacturing and testing of same or similar type equipment. The equipment manufacturer shall have and maintain ISO 9001 or ISO 9002 certification.

B. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of jurisdictional authorities.
2. NEC.
3. NEMA: ST1, ST20, 107, 250.
4. ANSI: C57.12.50, C57.12.51, Z55.1.
5. ASTM: D3487.
6. ANSI/IEEE: C57.12.00, C57.12.90, C57.12.91, C57.15, C57.94, C57.113, C57.124, C62.11.
7. IEEE: C57.12.01.
8. UL: 506, 1561, 1562.

C. Factory Testing:

1. General requirements for distribution transformers:

a. Perform design tests and short-circuit tests on one transformer of each type and rating furnished in this Contract.
b. Perform routine tests, impulse test and partial discharge test on each transformer furnished in this Contract.

2. Dry-type transformers: Perform design and routine tests in accordance with IEEE C57.12.01 and ANSI/IEEE C57.12.91 and the following additional tests:

a. Perform impulse test without using surge arrestors to protect the transformer.

b. Perform partial discharge test to establish partial discharge inception and extinction voltage during induced voltage test in accordance with ANSI/IEEE C57.124 and the following requirements:

1) Measure partial discharge in pico-coulombs at 10-percent increments when the voltage is raised from 70 percent to 200 percent and lowered from 200 percent to 70 percent of rated voltage during the induced voltage test to verify the following requirements:

a) Inception of partial discharge occurs above 120 percent of rated voltage when voltage is raised from 70 percent to 200 percent. At 120 percent, the partial discharge reading shall be 10 pico-coulombs or less.
b) Extinction of partial discharge occurs above 120 percent of rated voltage when voltage is lowered from 200 percent to 70 percent and partial discharge level is below 10 pico-coulombs.

c. Perform short-circuit tests in accordance with IEEE C57.12.01 and ANSI/IEEE C57.12.91.

3. Perform design and routine tests for general-purpose transformers in accordance with NEMA ST20.
4. Notify the Engineer not less than 14 days prior to factory testing to allow witnessing of tests.

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: In accordance with Section 16360.
2. Certification:

a. Furnish certified test report of all design and short-circuit tests performed on one transformer of each type and rating furnished in this Contract or on identical transformers built by same manufacturer within the last five years.
b. Furnish certified test report of all routine, impulse and partial discharge tests performed on each transformer furnished in this Contract.
c. Furnish certificates from manufacturers verifying that products conform to specified requirements. Include certificates with submittal of shop drawings.

3. Documentation:

a. Field-testing plan: In accordance with Section 16360.

4. Operation and Maintenance Manuals: In accordance with Section 16360.

1.04 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. Temporary Bracing: Where necessary, brace transformer for hoisting, lowering and skidding into position. Label temporary internal bracing: TEMPORARY - REMOVE BEFORE OPERATION.

C. Protection Against Concealed Damage: Include within shipping container mechanical impact recorder of rating recommended by manufacturer for shipment by railroad and submit impact-record chart with manufacturer's instructions for disposition of damaged materials.

D. Store transformers in secure and dry storage facility.

1.05 OPERATION AND MAINTENANCE TRAINING:

A. In accordance with the General Requirements.

PART 2 – PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. Not Used

B. Not Used

C. General-Purpose and Specialty Transformer:

1. NEMA ST20 and ST1, UL 506 and 1561, indoor, dry, double-wound with insulated copper conductor, suitable for operation on 60 Hertz.
2. Rating:

   a. kVA rating: As shown.
   b. Voltage rating:

      1) Three-phase transformers: 480 volts primary to 208Y/120 volts secondary with secondary neutral brought out.

3. Enclosures:

   a. Above 9 kVA: Ventilated, NEMA 250, Type 2 drip-proof enclosure with removable front panel and louvers to prevent entrance of falling dirt and accidental access to live parts, and with lifting brackets or holes.
   b. 45 kVA and below: Wall-mounted unless otherwise shown.

4. Insulation system as specified below, capable of withstanding full-wave impulse of 10 kV.

kVA Rating	Insulation System
3-30	185C

5. Maximum allowable temperature rise under continuous full-load above an average ambient temperature of 30C and maximum of 40C.

kVA Rating	3 -30
By winding resistance	115C
By hottest spot in winding	145C

6. Taps:

a. Tap-changing links providing taps as follows, capable of delivering rated output in each position.
b. Three-phase transformers: Provide taps on primary side in accordance with the following:

kVA Rating	Quantity		Taps Size:	Percent-age of rated voltage
9 - 15	2		5	below

PART 3 – EXECUTION

3.01 INSTALLATION:

A. Install each transformer in position shown and in accordance with manufacturer's recommendations and NEC requirements.

B. Make power-conductor and control-wire connections in accordance with manufacturer's drawings, Section 16125 and as shown.

C. Ground each transformer and automatic voltage regulator as shown and in accordance with Section 16060.

D. Connect space heater circuit to prevent condensation during installation.

3.02 FIELD QUALITY CONTROL:

A. Prior to testing, check transformer installation in accordance with ANSI/IEEE C57.94.

B. Submit field-testing plan including, but not limited to, the following tests. Furnish equipment and perform the following tests in the presence of Engineer, in accordance with approved procedure:

1. General-purpose and specialty transformers:

a. Perform insulation-resistance tests winding-to-winding and winding-to-ground. Record and correct resistance value to temperature.
b. Perform ac high-voltage tests between high-voltage winding and low-voltage winding, between high-voltage winding and ground and between low-voltage winding and ground. Perform tests at 65 percent of factory test voltage for one-minute duration.
c. Test voltage ratio of each tap. Results not to deviate more than 0.5 percent from calculated ratio. Set taps as directed.
d. Check polarity by means of vector check.

C. Submit certified test reports.

END OF SECTION

SECTION 16425

MOTOR STARTERS AND CONTROL CENTERS

PART 1 – GENERAL

1.01 DESCRIPTION

A. This section specifies work pertaining to motor starters and control centers.

1.02 QUALITY ASSURANCE

A. A. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of the Authority Having Jurisdiction.
2. National Electrical Code (NEC) 2011.
3. NEMA AB1, ICS-2, ICS-2.3, 250.
4. ANSI: Z55.1.
5. ASTM: A47/A47M-99/06, A653/A6 (3M-07), B187/B187M-06.
6. UL: 845, Electrical Construction Materials Directory
7. ITS: Directory of ITS Listed Products.
8. The equipment manufacturer shall maintain an ISO 9001 or ISO9002 certification.
9. National Fire Protection Association (NFPA) 130, 2014 Edition.

B. The following items to be listed or labeled per referenced UL or ITS directory.

1. Motor starter.
2. Combination starters.
3. Motor circuit protectors.
4. Motor control centers.

1.03 SUBMITTALS

A. Refer to the Contract Documents.

1.04 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 and control centers in secure and dry storage facility.

C. The Contractor shall coordinate and participate with the overall commissioning activities in accordance with the Contract Documents.

1.05 COMMISSIONING

A. The Contractor shall coordinate and participate with the overall commissioning activities in accordance with the Contract Documents.

PART 2 – PRODUCTS

2.01 PRODUCTS AND MATERIALS

A. Variable Frequency Drives:

1. As specified in Section 16480.

B. Motor Control Centers:

1. NEMA ICS-2.3, Class 1, Type B, rated 480-volt, three-phase, 60 Hertz, totally enclosed, deadfront, free-standing, modular assembly having vertical and horizontal buses, wireways, compartments equipped with circuit breakers, MCP and starters as shown.
2. Motor starter: Across-the-line magnetic or autotransformer starter, as shown and specified, with tin-plated stub assembly for connecting to vertical buses in unit compartment.
3. Circuit breaker:

    a. Branch circuit breaker: One 480-volt, three-pole MCP for each unit compartment.

4. Indicator light: One red light mounted on each unit compartment showing ON position of circuit breaker.
5. Nameplate:
6. Each motor control center labeled with 1-1/2-inch-wide nameplate showing designation in one-inch high characters.
7. Each compartment labeled with one-inch wide nameplate showing function and number of the motor controlled in 1/2- inch high characters.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Embed iron sills for anchoring motor control center flush with raised concrete pad. The Contractor shall coordinate location of iron sills with pouring of concrete pad.

B. Install motor control center devices as shown in accordance with manufacturer's recommendations, the NEC and Section 16225.

C. Install conduit in accordance with Section 16130 and the NEC.

D. Application:

1. Across-the-line starter permitted only for motors less than 25 HP.
2. Use VFD’s for vent shaft fans and pump motors.

E. Connect power cable and control wire as recommended by manufacturers and as follows:

1. Make power-cable and control-cable connections to circuit breakers and across-the-line magnetic 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.

F. Ground complete motor control center in accordance with Section 16060.

G. Apply touch-up paint as necessary.

3.02 TESTING

A. Refer to the Contract Documents.

END OF SECTION

SECTION **16435**

LOW-VOLTAGE SWITCHGEAR AND SWITCHBOARD

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies providing 480-volt switchgear and switchboard.

B. Related Work Specified Elsewhere:

1. Raceways, boxes, and cabinets: Section 16130.
2. Wire connection accessories: Section 16125.
3. Grounding and bonding: Section 16060.
4. Circuit breakers, panelboards, and load centers: Section 16440.

1.02 QUALITY ASSURANCE:

A. Qualifications:

1. Select manufacturer regularly engaged in production of switchgears and switchboards.
2. Furnish low-voltage switchgear, switchboard, and their main components from one manufacturer.

B. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of jurisdictional authorities.
2. NEC.
3. NEMA: PB2.
4. ANSI: C37.16, C37.17, C37.50, Z55.1.
5. UL: 891.
6. ASTM: B187.
7. ANSI/IEEE: C37.13, C37.20.1, C57.13.

C. Factory Testing: Submit design tests or certified copies of test reports on identical units performed for each type and rating of circuit breakers as assembled in its complete switchgear or switchboard unit including bus compartment.

1. Circuit breaker tests in accordance with requirements of ANSI C37.50 and including the following:

a. Design test:

1) Trip-device calibration-check test.
2) AC dielectric withstand-voltage test.
3) Continuous-current test.
4) Overload-switching test.
5) Endurance tests.
6) Short-circuit current tests.
7) Short-time current test.

b. Production tests: All applicable tests in accordance with the requirements of ANSI C37.50.

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: In accordance with Section 16360.
2. Certification: Certified test reports for specified factory testing.
3. Documentation:

    a. Short-circuit calculations and system coordination study: In accordance with Section 16360.
    b. Field-testing plan: In accordance with Section 16360.

4. Operation and Maintenance Manuals: In accordance with Section 16360.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Ship each unit securely packaged, braced and labeled for safe handling in shipment and to avoid damage and distortion.

B. Protection Against Concealed Damage: Include within shipping container mechanical impact recorder of rating recommended by manufacturer for shipment by railroad and submit impact-record chart with manufacturer's instruction for disposition for damaged material.

C. Assembly for Shipment:

1. Removable circuit-breaker elements packaged separately.

1.05 OPERATIONS AND MAINTENANCE TRAINING:

A. In accordance with the General Requirements and Section 16360.

PART 2 – PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. General Requirements for Switchboards:

1. NEMA PB2, UL 891.
2. Ratings:

    a. Normal voltage: 480 volts.
    b. Frequency: 60 Hertz.
    c. Rated continuous current: As shown.
    d. Short-circuit rating: As shown.

3. Molded-case circuit breakers: Section 16440.
4. Control wiring:

    a. Insulation rated 600 volts, Type SIS, copper, No. 14 AWG minimum. Flexible, Class C or higher, stranded wire used for wiring across hinged joints.
    b. One continuous length of wire used between terminals without splices or taps.
    c. Connections made at terminal of device, on terminal blocks or at control bus, using tinned copper-ring compression terminals with insulated sleeve.

d. Interconnect wiring between compartments terminated on terminal blocks before being wired to components.
e. Terminal blocks: With screw-type terminals, circuit-marking strips for indicating wire number, phenolic-laminated dustcover and 10-percent minimum spare terminal points.
f. For each individual wire, same identification used on each terminal block marking strip.

PART 3 – EXECUTION

3.01 INSTALLATION:

A. Install conduits and raceways as shown and in accordance with the Section 16130.

B. Make power-cable and control-wire connections as shown and as follows:

1. Make power-cable and control-wire connections to circuit breakers 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.

C. Make grounding connections as shown and in accordance with Section 16060.

END OF SECTION

SECTION 16440

CIRCUIT BREAKERS, PANELBOARDS AND LOAD CENTERS

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies furnishing, installing, connecting and testing of circuit breakers, panelboards and load centers.

B. Related Work Specified Elsewhere:

1. Raceways, boxes and cabinets: Section 16130.
2. Wire, cable and busways: Section 16120.
3. Wire connection accessories: Section 16125.
4. Grounding and bonding: Section 16060.
5. Field painting: Section 09920.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of the jurisdictional authorities.
2. NEC.
3. NEMA: AB1, PB1, ST20, 250.
4. ANSI: Z55.1.
5. UL: 50, 67, 198C, 489, 891, Electrical Construction Materials Directory.
6. ASTM: A276, B187.
7. ITS: Directory of ITS Listed Products.

B. Source Quality Control:

1. Each item 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.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Mark each circuit breaker, panelboard and transformer 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

2.01 PRODUCTS AND MATERIALS:

A. General Requirements:

1. Interchangeability: Components of the same type, size, rating, functional characteristics and make are to be interchangeable.
2. Finish for enclosures for enclosed circuit breakers, panelboards, emergency-service panelboards and load centers:

   a. Clean and degrease metallic surfaces.
   b. Prime with zinc primer.
   c. Finish with one coat of light-gray enamel, ANSI Z55.1, Color 61. Minimum dry-film thickness: Two mils.

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. Shunt-trip device for tripping by ground-fault relay as shown. Frame size 225 amperes and above equipped with interchangeable thermal trip and adjustable magnetic-trip unit. Designed to carry continuous rating in ambient temperature of 40C with the following parameters as shown:

1. Number of poles.
2. Rated voltage.
3. Rated interrupting current.
4. Trip setting.
5. Frame size.

C. Panelboard:

1. NEMA PB1, UL 67.
2. Enclosure:

   a. UL 50.
   b. Galvanized steel, surface-mounted unless otherwise shown.
   c. Type:

      1) Aboveground indoor locations and electrical rooms: NEMA 250, Type 1.
      2) Tunnel areas and underground locations, except electrical rooms: NEMA 250, Type 12.
      3) Outdoor locations: NEMA 250, Type 3R.

d. Gutter size:

Main Bus Rating Amperes	Minimum Top and Bottom Gutter Size in Inches	Minimum Side Gutter Size in Inches
100 and below	4	4
225	6	4
400 and over	8	4

e. Interior components mounted on backplate of reinforced steel for rigid support and accurate alignment.
f. Provide latch and handle in accordance with UL 50; screw fastenings will not be accepted in lieu of latch.
g. Provision for enclosure grounding.

3. Busbars:

a. ASTM B187.
b. 98-percent-conductivity copper.
c. Contact surface silver-plated or tin-plated.
d. Rating of neutral and ground bus: Equal to that of phase bus.
e. Neutral bus mounted on insulating block.
f. Neutral and ground busbars equipped with integral mechanical connectors.

4. AC panelboards:

a. Type of service: Three-phase, four-wire, 277/480 volt or 120/208 volt or as shown.
b. Type of main: Main lugs or circuit breakers or integrally fused circuit breakers as shown, conforming to requirements specified, located at top or bottom as necessary
c. Branch circuit: Circuit breakers or integrally fused circuit breakers as shown, conforming to requirements specified, number of circuits as shown.
d. Circuit breaker: Trip device coordinated with that of upstream circuit breakers to provide selective tripping.
e. Suitable for service entrance where necessary.

5. Fuse time-current characteristic coordinated with upstream fuse time-current characteristic to provide selective overcurrent tripping.

D. Nameplates:

1. Three-ply, laminated phenolic plates, engraved through black face to white core and attached by stainless-steel rivets or screws.
2. Lettering: Vertical gothic using round or square cutter. V-shape groove is prohibited.
3. Each panelboard labeled with nameplate one-inch high bearing ½-inch high inscriptions as appropriate.

PART 3 – EXECUTION

3.01 INSTALLATION:

A. Install panelboards at locations shown, with bottom not less than 12 inches above floor. Use multiple-section panelboards to meet such spacings if necessary.

B. Mount panelboards and load centers with front straight and plumb.

C. 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 panelboard.

D. Make conduit connections in accordance with Section 16130.

E. Make power cable connections to circuit breakers, integrally fused circuit breakers, fused switch units, neutral and ground bus bars in panelboard and load centers and enclosed circuit breakers 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.

F. Ground panelboards in accordance with Section 16060 and the NEC.

G. Apply matching touch-up paint where necessary.

3.02 DIRECTORY OF CIRCUITS:

A. Furnish each panelboard and load center with legibly printed circuit directory located on inside of enclosure.

3.03 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. Panel boards: Perform insulation-resistance tests of each bus section phase-to-phase and phase-to-ground for one minute using 1,000V megger. Insulation resistance to be not less than manufacturer's recommended minimum or two megohms minimum.
3. Test circuit connections in accordance with wiring diagram.
4. Test panelboard enclosures for continuity to grounding system.
5. Check cable connections to circuit breakers and fused switch unit for tightness.
6. Check setting of adjustable magnetic trips for compliance with approved coordination study.

B. Submit certified test reports.

END OF SECTION

SECTION 16480

VARIABLE FREQUENCY DRIVES

PART 1 – GENERAL

1.01 SUMMARY:

A. This Section includes furnishing and installing variable speed drives for operation of 480V, 3 phase, 60 Hz, centrifugal pump and fan motors (HP as required).

B. The work shall also include drawings in AutoCAD 2014 format that show the installation of the new VFDs along with power wiring.

C. The VFDs shall have provisions to be controlled and operated from an existing SCADA system; the Contractor that furnishes and installs the VFDs shall verify their compatibility with said system.

D. The VFDs installation shall use new power wiring and conduit which shall meet all existing code requirements. Any devices, wiring, cabling, conduit or other appurtenances that are required for a complete installation other than connection to the SCADA system shall be provided by the Contractor at no additional cost to the Authority.

1.02 REFERENCES:

A. Provide equipment in full accordance with the latest rules, Regulations, and standards of:

1. Institute of Electrical and Electronic Engineers (IEEE)
    a. Standard 519-1992, IEEE Guide for Harmonic Content and Control.
2. Underwriters laboratories
    a. UL508C
3. National Electrical Manufacturer's Association (NEMA)
    a. ICS 7.0, AC Adjustable Speed Drives
4. IEC 16800 Parts 1 and 2
5. National Electric Code (NEC)
    a. NEC 430.120, Adjustable-Speed Drive Systems
6. International Building Code (IBC)
    a. IBC 2006 Seismic – referencing ASC 7-05 and ICC AC-156

B. Qualifications:

1. VFDs and options shall be UL listed as a complete assembly. VFD's that require the customer to supply external fuses for the VFD to be UL listed are not acceptable. VFDs with red label UL stickers, requiring additional branch circuit protection are not acceptable. The base VFD shall be UL listed for 100 KAIC without the need for input fuses.
2. Acceptable Manufacturers

a. ABB ACS550 Series
b. Danfoss VLT AQUA Series.
c. Allen-Bradley Power Flex 700 Series.
d. Cutler Hammer

3. The VFD manufacturer shall have available a comprehensive, Drive Computer Based Training (CBT) product. The CBT product shall include detailed, interactive sections covering VFD unpacking, proper mechanical and electrical installation, and programming. The CBT product shall allow the user to provide just-in-time training to new personnel or refresher training for maintenance and repair personnel on the user's site. The CBT product shall be repeatable, precise and shall include record keeping capability. The CBT product shall record answers to simulations and tests by student ID number. The CBT product must be professionally produced and have interactive sections, student tests, and include video clips of proper wiring and installation.

1.03 SUBMITTALS

A. Submittals shall include the following information:

1. Outline dimensions, conduit entry locations and weight.
2. Customer connection and power wiring diagrams.
3. Complete technical product description include a complete list of options provided. Any portions of this specification not met must be clearly indicated or the supplier and contractor shall be liable to provide all additional components required to meet this specification.
4. Compliance to IEEE 519 – harmonic analysis for particular jobsite including total harmonic voltage distortion and total harmonic current distortion (TDD).

   a. The VFD manufacturer shall provide calculations; specific to this installation, showing total harmonic voltage distortion is less than 5%. Input and output filters shall be sized and provided as required by the VFD manufacturer to ensure compliance with IEEE standard 519. All VFD's shall include a minimum of 5% impedance reactors, **no exceptions**.

PART 2 – PRODUCTS

2.01 VARIABLE FREQUENCY DRIVES

A. The VFD package as specified herein shall be enclosed in a UL Listed Type enclosure, exceeding NEMA enclosure design criteria (enclosures with only NEMA ratings are not acceptable), completely assembled and tested by the manufacturer in an ISO9001 facility. The VFD tolerated voltage window shall allow the VFD to operate from a line of +30% nominal, and -35% nominal voltage as a minimum.

1. Environmental operating conditions: VFDs shall be capable of continuous operation at 0 to 50^0 C (32 to 122^0 F) ambient temperature as per VFD manufacturers documented/submittal data or VFD must be oversized to meet these temperature requirements. Not acceptable are VFD's that can only operate at 40° C intermittently (average during a 24 hour period) and therefore must be oversized. Altitude 0 to 3300 feet above sea level, less than 95% humidity, non-condensing. All circuit boards shall have conformal coating.

2. Enclosure shall be rated UL Type 4X and shall be UL listed as a plenum rated VFD. VFD's without these ratings are not acceptable. NEMA only type 4X enclosures are not acceptable (must be UL Type 4X).

B. All VFDs shall have the following standard features:

1. All VFDs shall have the same customer interface, including digital display, and keypad, regardless of horsepower rating. The keypad shall be removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFDs.
2. The keypad shall include Local and Remote selections and manual speed control. The drive shall incorporate "bumpless transfer" of speed reference when switching between Local and Remote modes. There shall be fault reset and "Help" buttons on the keypad. The Help button shall include "on-line" assistance for programming and troubleshooting.
3. There shall be a built-in time clock in the VFD keypad. The clock shall have a battery back up with 10 years minimum life span. The clock shall be used to date and time stamp faults and record operating parameters at the time of fault. If the battery fails, the VFD shall automatically revert to hours of operation since initial power up. Capacitor back-up is not acceptable. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter sets and output Form-C relays. The VFD shall have a digital input that allows an override to the time clock (when in the off mode) for a programmable time frame. There shall be four (4) separate, independent timer functions that have both weekday and weekend settings.
4. The VFD's shall utilize pre-programmed application macros specifically designed to facilitate start-up. The Application Macros shall provide one command to reprogram all parameters and customer interfaces for a particular application to reduce programming time. The VFD shall have two user macros to allow the end-user to create and save custom settings.
5. The VFD shall have cooling fans that are designed for easy replacement. The fans shall be designed for replacement without requiring removing the VFD from the wall or removal of circuit boards. The VFD cooling fans shall operate only when required. To extend the fan and bearing operating life, the VFD shall cycle the cooling fans on and off as required.
6. The VFD shall be capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to set point without tripping or component damage (flying start).
7. The VFD shall have the ability to automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable.
8. The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds. The minimum FLA rating shall meet or exceed the values in the NEC/UL table 430.250 for 4-pole motors.
9. The VFD shall have internal 5% equivalent impedance to reduce the harmonics to the power line and to add protection from AC line transients. The 5% impedance may be from dual (positive and negative DC bus) reactors, or 5% AC line reactors. VFD's with only one DC reactor shall add an AC line reactor.
10. The input current rating of the VFD shall be no more than 3% greater than the output current rating. VFD's with higher input current ratings require the upstream wiring, protection devices, and source transformers to be oversized per NEC 430.120. Input and output current ratings must be shown on the VFD nameplate.

11. The VFD shall include a coordinated AC transient surge protection system consisting of 4-120 joule rated MOV's (phase to phase and phase to ground), a capacitor clamp, and 5% impedance reactors.
12. The VFD shall provide a programmable loss-of-load (broken belt / broken coupling) Form-C relay output. The drive shall be programmable to signal the loss-of-load condition via a keypad warning, Form-C relay output, and / or over the serial communications bus. The loss-of-load condition sensing algorithm shall include a programmable time delay that will allow for motor acceleration from zero speed without signaling a false loss-of-load condition.
13. The VFD shall have user programmable underload and overload curve functions to allow user defined indications of broken belt or mechanical failure / jam condition causing motor overload
14. If the input reference (4-20mA or 2-10V) is lost, the VFD shall give the user the option of either (1) stopping and displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last good reference received, or (4) cause a warning to be issued, as selected by the user. The drive shall be programmable to signal this condition via a keypad warning, Form-C relay output and / or over the serial communication bus.
15. The VFD shall have programmable "Sleep" and "Wake up" functions to allow the drive to be started and stopped from the level of a process feedback signal.
16. The VFD shall have the ability to program local currency and provide display of energy saved as well as tons of CO_2 reduced.

C. All VFDs to have the following adjustments:

1. Three (3) programmable critical frequency lockout ranges to prevent the VFD from operating the load continuously at an unstable speed. The lockout range must be fully adjustable, from 0 to full speed.
2. Two (2) PID Set point controllers shall be standard in the drive, allowing pressure or flow signals to be connected to the VFD, using the microprocessor in the VFD for the closed-loop control. The VFD shall have 250 ma of 24 VDC auxiliary power and be capable of loop powering a transmitter supplied by others. The PID set point shall be adjustable from the VFD keypad, analog inputs, or over the communications bus. There shall be two independent parameter sets for the PID controller and the capability to switch between the parameter sets via a digital input, serial communications or from the keypad. The independent parameter sets are typically used for night setback, switching between summer and winter set points, etc.
3. There shall be an independent, second PID loop that can utilize the second analog input and modulate one of the analog outputs to maintain the set point of an independent process (ie. valves, dampers, etc.). All set points, process variables, etc. to be accessible from the serial communication network.
4. Two (2) programmable analog inputs shall accept current or voltage signals.
5. Two (2) programmable analog outputs (0-20ma or 4-20 ma). The outputs may be programmed to output proportional to Frequency, Motor Speed, Output Voltage, Output Current, Motor Torque, Motor Power (kW), DC Bus voltage, Active Reference, Active Feedback, and other data.
6. Six (6) programmable digital inputs for maximum flexibility in interfacing with external devices. All digital inputs shall be programmable to initiate upon an application or removal of 24VDC or 24VAC.
7. Three (3) programmable, digital Form-C relay outputs. The relay outputs shall include programmable on and off delay times and adjustable hysteresis. The relays shall be rated for maximum switching current 8 amps at 24 VDC and 0.4 A at 250 VAC; Maximum

voltage 300 VDC and 250 VAC; continuous current rating of 2 amps RMS. Outputs shall be true Form-C type contacts; open collector outputs are not acceptable.

8. Run permissive circuit - There shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad, input contact closure, time-clock control, or serial communications), the VFD shall provide a dry contact closure that will signal the damper to open (VFD motor does not operate). When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to a VFD digital input and allows VFD motor operation. Two separate safety interlock inputs shall be provided. When either safety is opened, the motor shall be commanded to coast to stop and the damper shall be commanded to close. The keypad shall display “start enable 1 (or 2) missing”. The safety input status shall also be transmitted over the serial communications bus.
9. The VFD control shall include a programmable time delay for VFD start and a keypad indication that this time delay is active. A Form C relay output provides a contact closure to signal a plenum damper is open. This will allow the damper to be driven open before the motor operates. The time delay shall be field programmable from 0 – 120 seconds. Start delay shall be active regardless of the start command source (keypad command, input contact closure, time-clock control, or serial communications), and when switching from drive to bypass.
10. Seven (7) programmable preset speeds.
11. Two independently adjustable accel and decel ramps with 1 – 1800 seconds adjustable time ramps.
12. The VFD shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and reduce audible motor noise. The VFD shall have selectable software for optimization of motor noise, energy consumption, and motor speed control.
13. The VFD shall include a carrier frequency control circuit that reduces the carrier frequency based on actual VFD temperature that allows higher carrier frequency settings without derating the VFD.
14. The VFD shall include password protection against parameter changes.

D. The Keypad shall include a backlit LCD display. The display shall be in complete English words for programming and fault diagnostics (alpha-numeric codes are not acceptable). All VFD faults shall be displayed in English words. The keypad shall include a minimum of 14 assistants including:

1. Start-up assistant
2. Parameter assistants
    a. PID assistant
    b. Reference assistant
    c. I/O assistant
    d. Serial communications assistant
    e. Option module assistant
    f. Panel display assistant
    g. Low noise set-up assistant
3. Maintenance assistant
4. Troubleshooting assistant
5. Drive optimizer assistants

E. All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of three operating values from the list below shall be capable of being displayed at all times. The display shall be in complete English words (alpha-numeric codes are not acceptable):

a. Output Frequency
b. Motor Speed (RPM, %, or Engineering units)
c. Motor Current
d. Motor Torque
e. Motor Power (kW)
f. DC Bus Voltage
g. Output Voltage

F. Serial Communications

1. The VFD shall have an EIA-485 port as standard. The standard protocols shall be Modbus, [Optional protocols for Profibus, EtherNet, and DeviceNet shall be available.] Each individual drive shall have the protocol in the base VFD. The use of third party gateways and multiplexers is not acceptable.
2. Serial communication capabilities shall include, but not be limited to; run-stop control, speed set adjustment, proportional/integral/derivative PID control adjustments, current limit, accel/decel time adjustments, and lock and unlock the keypad. The drive shall have the capability of allowing the DDC to monitor feedback such as process variable feedback, output speed / frequency, current (in amps), % torque, power (kW), kilowatt hours (resettable), operating hours (resettable), and drive temperature. The DDC shall also be capable of monitoring the VFD relay output status, digital input status, and all analog input and analog output values. All diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote VFD fault reset shall be possible.
3. The VFD shall include an independent PID loop for customer use. The independent PID loop may be used for cooling tower bypass value control, chilled water value / hot water valve control, etc. Both the VFD PID control loop and the independent PID control loop shall continue functioning even if the serial communications connection is lost. As default, the VFD shall keep the last good set point command and last good DO & AO commands in memory in the event the serial communications connection is lost and continue controlling the process.

G. EMI / RFI filters. All VFD's shall include EMI/RFI filters. The onboard filters shall allow the VFD assembly to be CE Marked and the VFD shall meet product standard EN 61800-3 for the First Environment restricted level with up to 100 feet of motor cable. No Exceptions. Certified test reports shall be provided with the submittals confirming compliance to EN 61800-3, First Environment.

H. All VFD's through 75HP at 480 V shall be protected from input and output power mis-wiring. The VFD shall sense this condition and display an alarm on the keypad. The VFD shall not sustain damage from this power mis-wiring condition.

I. OPTIONAL FEATURES – Optional features to be furnished by the drive manufacturer. All optional features shall be UL Listed as a complete assembly and carry a UL508 label. The VFD with bypass and/or disconnect means enclosure door must be interlocked such that input power is turned off before the enclosure can be opened. The VFD with bypass and/or disconnect means as a package shall have a UL listed short circuit rating of 100,000 amps and shall be indicated on the UL data label.

J. The following shall be provided where bypass is required:

1. A complete factory wired and tested bypass system consisting of output and bypass contactors, a motor overload relay, a control power transformer with primary and secondary fusing, a cover mounted DRIVE-OFF-BYPASS selector switch, a service (isolation) switch and fast acting, current limiting VFD input fuses are required. Bypass designs, which have no VFD only fuses, or that incorporate fuses common to both the VFD and the bypass will not be accepted
2. An input circuit breaker with a door mounted external operating handle, interlocked with the enclosure door and lockable in the OFF position with up to three padlocks, to disconnect all input power from the drive and all internally mounted options.
3. Motor overload protection for the bypass mode is to be provided by a motor overload relay connected in both the drive and bypass modes of operation. The motor overload relay shall be an adjustable trip, bimetallic overload relay with a class 20 trip characteristic.
4. The drive output contactor and the bypass contactor are to be electrically interlocked to prevent simultaneous operation.
5. The bypass system shall NOT depend on the VFD for bypass operation. The bypass shall be completely functional even if the VFD has been removed from the enclosure for repair / replacement.

K. VFD with Bypass and/or Disconnect Means enclosures shall be UL Type/NEMA 4X.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Installation shall be the responsibility of the mechanical contractor. The contractor shall install the drive in accordance with the recommendations of the VFD manufacturer as outlined in the VFD installation manual.

B. Power wiring shall be completed by the electrical contractor, to NEC code 430.122 wiring requirements based on the VFD input current. Caution: VFDs supplied without internal reactors have substantially higher input current ratings, which may require larger input power wiring and branch circuit protection. The contractor shall complete all wiring in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

3.02 START-UP

A. Certified factory start-up shall be provided for each drive by a factory authorized service center. A certified start-up form shall be filled out for each drive with a copy provided to the owner, and a copy kept on file at the manufacturer.

3.03 PRODUCT SUPPORT

A. Factory trained application engineering and service personnel that are thoroughly familiar with the VFD products offered shall be locally available at both the specifying and installation locations. A toll free 24/365 technical support line shall be available.

B. A computer based training CD or 8-hour professionally generated video (VCR format) shall be provided to the owner at the time of project closeout. The training shall include installation, programming and operation of the VFD, bypass and serial communication.

3.04 WARRANTY

A. The VFD Product Warranty shall be 24 months from the date of certified start-up, not to exceed 30 months from the date of shipment. The warranty shall include all parts, labor, travel time and expenses. A toll free 24/365 technical support line shall be available.

END OF SECTION

SECTION 16525

LIGHTING FIXTURES AND MOUNTING POLES

PART 1 – GENERAL

1.01 DESCRIPTION:

A. This section specifies providing lighting fixtures and mounting poles.

B. Related Work Specified Elsewhere:

1.	Grounding and bonding:	Section 16060.
2.	Wire, cable and busways:	Section 16120.
3.	Wire connection accessories:	Section 16125.
4.	Raceways, boxes and cabinets:	Section 16130.
5.	Wiring and control devices:	Section 16145.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of jurisdictional authorities.
2. NEC.
3. UL: 496, 542, 1029, 1570, 1571, 1572, Electrical Construction Materials Directory.
4. FS: FF-B-588, FF-P-395, FF-S-325C.
5. MS: MIL-C-450.
6. FED STD: 595.
7. PEI: 1001.
8. SSPC: SP-8, SP-10.
9. ASTM: A53, A167, A276, A123, A507, A575, B26, B85, B117, B136, B137, B209, B221, B244, D635, D1056, D1400, D2240.
10. AASHTO: M314, LTS-3.
11. ITS: Directory of ITS Listed Products.
12. AA: Standard finishes as designated by the Aluminum Association and referenced in NAAMM Metal Finishes Manual.
13. ANSI/IEEE: C62.41.
14. IEEE Publication 587.
15. ANSI Standards.
16. FCC Rules and Regulations, Part 15, Part 18.
17. NEMA 1
18. AISI.
19. IES: RP-20

B. Each lighting fixture to be labeled or 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:

a. Include photometric curves.

2. Samples: One of each type of fixture.
3. Certification:

    a. Verification that each fixture is in compliance with applicable codes, regulations, reference standards and specifications for the location at which it is to be used. Indicate requirements that each fixture meets.
    b. Calculations: Submit calculations by a professional engineer registered in the jurisdiction where material is to be installed certifying that assemblies of foundation, anchor bolts, pole, arms and luminaire will withstand specified wind pressure, wind speed, stress, deflection, vibration and fatigue.

1.04 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 lighting fixtures and mounting poles in secure and dry storage facility.

1.05 WARRANTY:

A. Globes and Diffusers: In addition to warranty requirements of the General Provisions, furnish warranty against discoloration and distortion for a total of four years.

B. Lamps: Warrant the life of lamps for periods specified.

PART 2 – PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. General Requirements for Lighting Fixtures:

1. Interchangeability: Components of same type, size, rating, functional characteristics and make are to be interchangeable.
2. In accordance with UL 1570, UL 1571 and UL 1572.
3. Materials:

    a. Steel:

        1) Sheet: ASTM A507, 22-gauge minimum.
        2) Bar: ASTM A575.
        3) Sheet and plate: ASTM B209.

4. Lamps:

    a. In accordance with applicable ANSI Standards.
    b. Fluorescent:

        1) Wattage and size: As shown or specified.
        2) Color: Warm white.
        3) Type:

            a) F32T8/WW, F48T12/WW/SHO, F72T12/WW/SHO, and F96T12/WW/SHO: Rapid start.

4) Rated life:

a) F32T8/WW: 20,000 hours.

5) Base:

a) F32T8/WW: Medium bi-pin.

5. Lampholders:

a. Fluorescent:

1) In accordance with UL 542.
2) Rated 660 watts, 600 volts.
3) Integral starter holder for preheat-type lamps, with starter.
4) White, thermosetting phenolic-compound base and body, silver-plated phosphorous-bronze contacts, self-aligning neoprene gasket face.

6. Ballasts:

a. Fluorescent lamps:

1) FCC part 15 subpart J, UL listed Class P.
2) Operable on 120-volt or 277-volt, 60 Hertz, as shown or necessary, type and load rating suitable for associated lamps.
3) Capable of starting lamps at ambient temperature as follows:

a) F32T8/WW lamps: Zero degree F.

4) Sound rating:

a) For use with F32T8/WW lamps installed in office areas: A.
b) For use with F32T8/WW lamps installed in ancillary areas: B or better.

5) Maximum utilization of two-lamp ballasts in public-area lighting fixtures.
6) Equipped with individual fuse protection, installed in the fixture wiring channel.

7. Fixture body and housing: Shape, size and material as shown.
8. Reflector: Shape, size and material as shown. Aluminum or stainless steel polished to mirror finish unless otherwise shown. Minimum thickness 22 gauge unless otherwise shown.
9. Fixture wire: Section 16120.
10. Hardware:

a. Latches, catches, release mechanisms, hinges, screws, bolts, studs, nuts, rivets, washers and springs. Heavy-duty stainless steel or bronze, as shown.
b. Latches and catches: Captive-type.
c. Operating hardware: Self-retaining type.

11. Construction:

a. Fixture body, reflectors, wiring channels, end caps and castings formed so as to prevent buckling or distortion.
b. Minimum of two wire clips provided in wiring channel to support wiring. Self-cleaning air filter provided on breather ports.
c. Seams and joints continuously welded and ground smooth.

d. When aluminum will be in contact with dissimilar metal, separate contact surfaces with gasket, nonabsorptive tape, or coating to prevent corrosion.

12. Finish:

a. Baked enamel: Nonspecular finish consisting of six-stage hot-cleaning wash, phosphate coat, prime coat, and finish coat of sprayed white or other color acrylic enamel as shown, baked at 350F for a minimum of 30 minutes, with the following additional requirements:

1) Dry-film thickness (DFT) per ASTM D1400: 1.25 mils minimum.
2) Undercutting of enamel film from scored line after exposing to 10-percent salt spray for 1,500 hours, per ASTM B117: 0.067-inch maximum.
3) Baked white enamel after 100 hours exposure to fadeometer: 86-percent minimum reflectance factors, no appreciable visual color change.
4) Bronze color: FED STD 595, Color No. 20040.

13. Mark each fixture and its components in accordance with applicable reference standard.
14. Conduit: Section 16130.
15. Connectors: Section 16125.
16. Fasteners: Size and type shown or best suited to use.

a. Expansion anchors: FS FF-S-325C, Group II, Type 3, Class 1, stainless steel, Type 303.
b. Toggle bolts: FS FF-B-588.
c. Powder-actuated: FS FF-P-395.
d. Finish: Where exposed, custom finish exposed parts to match surface being fastened.

2.02 LIGHTING FIXTURES:

A. Tunnel and Ancillary-Space Lighting Fixtures: Types as shown and as follows:

1. Type 1 fixture:

a. Open, industrial-type, fluorescent.
b. Lamps: Two 32-watt F32T8/WW.
c. Body: Aluminum or 20-gauge steel channel-shaped body, end plates, cover and reflector. Knockouts in body and end plates as shown. Attach end plates to body with noncorrosive screws. Double-strength construction for steel channel.
d. Finish:

1) Channel, end plates, and cover:

a) Steel: White baked enamel.
b) Aluminum: Clear anodic coating.

2) Reflector: White baked enamel for aluminum and steel.

PART 3 – EXECUTION

3.01 INSTALLATION:

A. Install lighting fixtures of types shown at locations shown as follows:

1. Mount fixtures rigidly in place. Use expansion anchors and machine screws for concrete surfaces and toggle bolts for hollow concrete-masonry surfaces. Use appropriate fasteners for attachment to other surfaces. Support lighting fixtures independent of suspended acoustical-panel ceiling systems.
2. Mount fixtures plumb, level and in straight lines. Install stems of suspended fixtures plumb. Group-mounted fluorescent fixtures to appear as one unit.
3. Install 12-inch minimum length of liquid-tight flexible conduit for connection between fixture and outlet box unless otherwise shown in accordance with Section 16130. Use fixture wire from outlet box in branch circuit to lighting fixture in accordance with Section 16120, and connect fixtures to branch circuit in accordance with Section 16125.

3.02 FIELD QUALITY CONTROL:

A. Testing:

1. Furnish necessary personnel and equipment and perform tests and adjustments in the presence of the Engineer. Schedule adjustment of exterior installations to occur during hours of darkness.
2. Test lighting circuits for continuity and operation.
3. Test fixtures for continuity of grounding system.
4. Aim and adjust fixtures to provide distribution pattern approximately as shown and as approved.

END OF SECTION