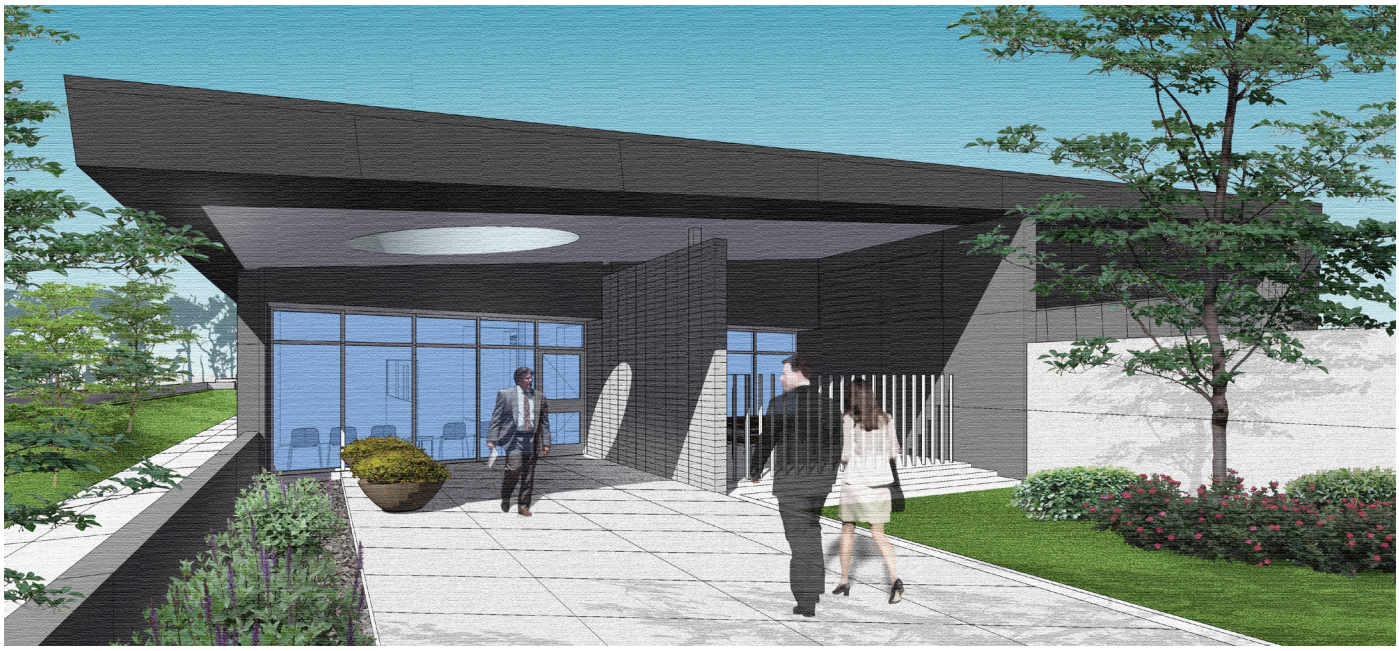
Project Manual (Specifications)

Northeast Corner of Krentel Road and Krentel Road (STPCD 9-1-1)
St. Tammany Parish, Louisiana

15 JUNE 2016

VOL. 3

Volume 3



gla
gabor lorant architects inc.
3326 N. 3rd Avenue Suite 200
Phoenix, Arizona 85013-4302 | 602.667.9090 | gaborlorant.com

St. Tammany Parish Communications District (STPCD)
Covington, LA
New 911 Dispatch Center - Lacombe, LA
Construction Documents - June 2016

SECTION 21 00 00

FIRE PROTECTION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. As a mission critical facility a single qualified Fire Protection Engineer shall be provided as part of the Contractor's team to design the key Fire Protection systems and to assure that the best practice integration of all related key sub-system components is accomplished to deliver a complete, well integrated, and highly functional fire protection system. The final systems shall effectively detect and suppress fires within the facility and communicate all conditions, alarms, execute necessary sequences of operation, and report status of key elements to the BCS. The Fire Protection Engineer will submit all proposed system submittals and shop drawings to the Authority Having Jurisdiction and obtain approval prior to ordering or constructing any fire protection systems. This Section outlines the requirements for the engineered fire protection system that include the following:

1. Automatic wet fire suppression system.
2. Automatic pre-action system.
3. Water storage tanks and booster pump system.
4. Detection and alarm devices including remote alarms and panels.
5. Clean-agent fire extinguishing system.
6. Connection devices and wiring between fire protection systems including tie into the building control system ("BCS") to communicate all conditions, alarms and status of key fire protection system elements.
7. Assure Fire Protection System design comply with 2010 Edition of NFPA 1221 Part 4.5
8. Assist facility management with drafting an overall Emergency Fire Plan per NFPA 1221 Part 4.5.6 and a Damage Control Plan per Part 4.5.7
9. Integration of all Fire Protection System and related sub-system Sequences of Operation with the overall Emergency Fire Plan and Damage Control Plan.
10. Coordination with the mechanical, plumbing, electrical, and special systems contractors to assure sequences of operation of the various sub-systems integrate into the Fire Protection System, Emergency Fire Plan and Damage Control Plan without conflict.
11. Specification of any signage on fire protection devices and systems to direct personnel in the event of an emergency.
12. Training of facility personnel in operation and maintenance of each of the fire protection systems referenced herein.

B. ROLE OF THE FIRE PROTECTION ENGINEER

The Fire Protection Engineer shall coordinate with the Authority Having Jurisdiction, the General Contractor, the various subcontractors, and the Architect and Engineering design team. The Fire Protection Engineer shall be furnished by the Contractor and shall not be furnished by the Architect or Engineers on the design team.

C. RELATED SPECIFICATION SECTIONS

21 00 00	Fire Protection Systems
21 10 00	Automatic Wet Sprinkler System
21 22 00	Clean-Agent Fire-Extinguishing Systems
10 44 00	Fire Protection Specialties
28 31 00	Fire Detection and Alarm
23 33 13	Combination Fire Smoke Dampers and Dynamic Fire Dampers
23 09 00	Controls Building Automation System “BAS”
26 23 13	Emergency Power Sequence of Operations

1.2 REFERENCES

A. The current editions of the following standards are part of this Section:
1. International Building Code and required references
2. NFPA 70 – National Electric Code
3. NFPA 72 – National Fire Alarm Code
4. NFPA 75 – Standard for the Protection of Electronic Computer/Data Processing Equipment
5. NFPA 2001 – Clean Agent Fire Extinguishing Systems
6. NFPA 1221 – Standard for the Installation, Maintenance, and Emergency Services Communication Requirements 2010 Edition

1.3 QUALIFICATIONS

A. Fire Protection Engineer shall be a Louisiana Registered Engineer with demonstrated Fire Protection system design and construction administration experience on similar mission critical, data center, and emergency first responder facilities. Fire Protection Engineer proposed to be provided by the Contractor will furnish all qualifications to the Client and must be acceptable to the Client and the Authority Having Jurisdiction prior to commencing the work specified.

1.4 SUBMITTALS

A. Product Data: Submit for all Fire Protection System equipment and Engineer Sealed shop drawings including:
1. Automatic wet fire suppression system.
2. Automatic pre-action system.
3. Water storage tanks and booster pump system.
4. Detection and alarm devices including remote alarms and panels.
5. Clean-agent fire extinguishing system.
6. Sequences of operation of all systems along with any required modifications to sequences of operation of any other MPE systems.
7. Draft of an overall Emergency Fire Plan per NFPA 1221 Part 4.5.6
8. Draft of a Damage Control Plan per NFPA 1221 Part 4.5.7
9. Signage plan for emergency systems
10. Training plan for the facility managers for all Fire Protection Systems

END OF SECTION

SECTION 21 10 00

AUTOMATIC WET SPRINKLER SYSTEM

PART 1 - GENERAL

1.1 GENERAL DESCRIPTION

A. This section describes requirements necessary to install an automatic fire sprinkler system per the latest version of referenced codes. See Civil plan for location of well, tanks, pumps, fire main, fire riser, connection, etc. See Architectural plan set for location of fire riser room, structural, mechanical, electrical and plumbing systems. Work in this section includes, but is not limited to, the following principal items:

1. The design, permitting, and installation of a complete automatic fire sprinkler system as required by national and local codes that meets the requirements and gains the approval of all authorities having jurisdiction. Securing and payment for all necessary permits and inspections as required to complete the installation per the Plans and City requirements.
2. Field verification of all dimensions. No extra charges or compensation will be allowed for any differences between actual dimensions and measurements indicated or for re-routing to avoid structure or other impedances as these are to be expected.
3. Provide (2) water storage tanks per codes referenced and per a002 which are required to be steel tanks of the gallons storage indicated as a minimum. Tanks shall be potable water tanks suitable for storage of adequate quantities of water to provide fire protection in the event of a fire and in the event of a prolonged well outage provide emergency water supplies to the facility.
4. Provide (1) fire booster pump per codes referenced and per a002.
5. Provide (2) water booster pumps at the tanks to supply up to 80gpm and 80 psig supply as backup for the domestic water system.
6. Provide miscellaneous tank and piping appurtenances including: tank vents, tank main valves in and out of tank, tank drain valve, piping, overflow/overfill drain, control valves, pressure relief valves, back-check valves where necessary, reduced pressure principle backflow preventer to separate potable water supply from non-potable fire protection water systems, valves to isolate pumps for service, stainless steel glass faced pressure gauges on pump inlets and outlets, pipe supports, tank foundations sealed by a structural engineer, and other miscellaneous components for a complete and operational system.
7. Provide miscellaneous controls including: tank level sensors and transmitters, control panels for pumps, pump status transmitter, pump flow sensor and transmitter, pressure sensor and transmitter on outlet pipe, and BACNet interface card for controls, coordination with the Building Automation System (BAS) system. BAS system graphics shall display tank water levels, pump status, pump pressure in and out.
8. Provide piping from the fire pump to the building riser including thrust blocks per code.
9. Provide complete riser including all valves, bells, gauges, and alarms.
10. Provide all steel fire protection piping.

11. Provide pre-action system where indicated on architectural plan a002 including all devices and air compressor for a complete preaction system.
12. During design provide coordination with the architect and the engineering team to integrate the fire protection system design with the site, building, MPE, and controls systems including fire alarm and BCS systems.
13. Provide a letter of acceptance from the Owners fire protection insurer and complete printed instructions on operation of system to the owner.
14. Furnishing miscellaneous materials such as brackets, hangers, steel supports for equipment, expansion joints, inspectors test connection, etc.
15. Provide heads for proper hazard classification. Provide baskets on heads in locations where physical abuse of the head may occur.
16. Provide alarm valves, zone valves, pumper connection, alarm gong, and miscellaneous equipment as required.
17. Coordinate installation of fire sprinkler system such that it does not interfere with any architectural, structural, mechanical or plumbing elements. Set height of fire protection piping per architect to avoid interference with ceilings. Coordinate with mechanical contractor to set pipe locations to avoid duct interference. Coordinate with all trades and project manager to assure compatibility of system installation.

1.2 CODES APPLICABLE

A. The current editions of the following standards are part of this Section:

1. International Building Code and required references
2. NFPA 70 – National Electric Code
3. NFPA 72 – National Fire Alarm Code
4. NFPA 75 – Standard for the Protection of Electronic Computer/Data Processing Equipment
5. NFPA 2001 – Clean Agent Fire Extinguishing Systems
6. NFPA 1221 – Standard for the Installation, Maintenance, and Emergency Services Communication Requirements 2010 Edition
7. NFPA 1142 – Water Supplies for Suburban and Rural Firefighting NFPA, Chapter 25, entitled, "Inspection and Testing of Fire Protection Systems."
8. NFPA, Chapter 24, entitled, "Installation of Private Fire Service Mains and Their Appurtenances.
9. NFPA, Chapter 291, entitled, "Flow Test Procedures."

B. Provide compliance with local codes and ordinances as required by Authority Having Jurisdiction.

1.3 RELATED SPECIFICATION SECTIONS

21 00 00 Fire Protection Systems
21 10 00 Automatic Wet Sprinkler System
21 22 00 Clean-Agent Fire-Extinguishing Systems
10 44 00 Fire Protection Specialties
28 31 00 Fire Detection and Alarm
23 33 13 Combination Fire Smoke Dampers and Dynamic Fire Dampers
23 09 00 Controls Building Automation System “BAS”
26 23 13 Emergency Power Sequence of Operations

1.4 RELATED PLANS TO REFERENCE

Civil Engineering Plans: depicting well, well pump, hydro-pneumatic tank, and piping to the building.

Architectural Plans: refer to Sheet a002 for “Fire Suppression Plan – Sprinklers” as well as NFPA 1142 fire protection system guidelines

1.5 QUALITY ASSURANCE

A. Provide a contractor's material and test certificate to the Owner and Authority Having Jurisdiction stating that the system has been designed and installed according to the national standards, state and local codes.

B. After completion of the installation, test entire system for acceptance by the authority having jurisdiction.

1.6 SUBMITTALS

A. A complete design including all system components, pipes and heads shall be created in AutoCAD.

B. A complete design of the fire protection system including hydraulic calculations sealed by a licensed Louisiana Fire Protection Engineer.

C. Fire Protection System Equipment Submittal: Prior to ordering equipment or permitting the fire plans, provide a submittal of all fire sprinkler equipment including: tanks, pumps, valves, pipe, riser, riser components, heads, valves, braces, hangers, and all related hardware integral to the system to the Architect for prior approval. Provide a plan in AutoCAD of the sprinkler piping showing plan view with mechanical ductwork shown in lighter background shade to confirm no interference. Provide plans in AutoCAD showing elevations through at least (8) key sections of the building showing no conflict with ductwork. Architect and Engineer reserve the right to review and modify fire protection pipe layout for optimal appearance of the finished piping system and conformance with the Architect’s desired final appearance of the systems. Following review of the submittal by Architect and Engineer, Fire Protection designer may begin permitting process. Review of the submittal does not relieve Fire Protection Engineer and Contractor from responsibility to provide a complete functional system meeting code, AHJ and Owner requirements of the system.

D. Conformance Certificate: Submit a letter of conformance for fire sprinkler system in accordance with local and national fire codes published by NFPA.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install sprinklers for total coverage of building in accordance with above referenced standards, latest edition. After completion of the installation, the entire system shall be tested for acceptance by the authority having jurisdiction, as required by NFPA 13. Provide suitable spare sprinkler cabinet with extra sprinklers with same rating as those installed and one sprinkler head wrench, all of which shall be installed at the location approved by the authority having jurisdiction.

B. Provide excavation and backfilling necessary for installation of underground piping in conformance with NFPA 24, "Standard for Installation of Private Fire Service Mains." Include all pipe and material to connect to main tanks per the Civil plans and running to the building's intended fire riser location.

C. All overhead piping shall be installed concealed behind finished walls or ceiling, unless plans indicate otherwise and shall be coordinated with other trades to avoid conflicts. Occupied portions of the building with exposed structural trusses shall not have fire protection piping installed below the bottom chord of the truss. Fire protection designer shall overlay mechanical ductwork plans on fire protection plans as a background lightly shaded element to verify that no conflicts exist in design.

D. Provide and install pipe sleeves in floor and walls. Fill the space between sleeve and pipe with an approved sealant to maintain a fire rating equal to the wall or floor. Sealant must be approved by the authority having jurisdiction and Architect.

E. After work has been installed, carefully fit around, close up, repair, patch and paint all chases, holes or openings as directed, to the entire satisfaction of the Architect.

F. Acceptance: Provide letter of guarantee stating compliance with the required national standards, state and local codes.

G. Provide next to the sprinkler riser a printed sheet, protected by transparent plastic cover, giving brief instructions regarding control, emergency procedures and other data for the fire sprinkler system.

H. After completion of installation and tests and prior to the building's acceptance, instruct the Owner of his/her designated representative in the operation of the sprinkler system.

I. Provide 3 ring binder of all sprinkler system components, operating procedures, maintenance procedures, warrantee information and instructions.

END OF SECTION

SECTION 21 22 00

FM 200 WATERLESS FIRE SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section outlines the requirements for the installation of a HFC-227ea (Heptafluropropane), hereafter referred to by the trade name FM-200, engineered total flooding fire suppression system with automatic control that includes the following:
   1. Piping and piping specialties.
   2. Extinguishing-agent containers.
   3. Extinguishing agent.
   4. Detection and alarm devices including remote alarm in the IT Office.
   5. System Specific Control and connection alarm panels.
   6. Accessories.
   7. Connection devices for and wiring between system components.

B. The work listed below shall be provided by others.
   1. 120 VAC power supply to the fire suppression system control panel.
   2. Interlock wiring and conduit for shutdown of HVAC, dampers, and/or electric power supplies, relays, or shunt trip breakers.
   3. Connection to the building fire alarm system.

1.2 REFERENCES

A. The current editions of the following standards are part of this Section:
   1. International Building Code and required references
   2. NFPA 70 – National Electric Code
   3. NFPA 72 – National Fire Alarm Code
   4. NFPA 75 – Standard for the Protection of Electronic Computer/Data Processing Equipment
   5. NFPA 2001 – Clean Agent Fire Extinguishing Systems

1.3 SYSTEM DESCRIPTION

A. Design system for Class A, B, and C fires per the requirements in NFPA 2001. Utilize safety factors specified in NFPA 2001 for the design concentrations for Class A, B, and C fires. Use FM-200 clean agent in concentration suitable for normally occupied areas.

B. Fire suppression system shall have it’s own supply of FM-200 in a modular storage design.

C. Sequence of Operation:
   1. First Alarm Condition:
      a. First Alarm condition is caused by any one detector in an active alarm state.
      b. The local alarm bell and an alarm in the IT office will be activated.
      c. The release panel will display text information regarding the alarm.
      d. Shut down of air condition and ventilation systems serving protected area.

e. An alarm signal will be sent to the building fire alarm system.
f. The system will remain in this state until some action is taken to reset the system or until another detector alarms.

2. Second Alarm Condition:
   a. Second Alarm condition is caused if there are two detectors in an active alarm state.
   b. The local alarm horn/strobe will be activated.
   c. The release panel will display text information regarding the alarm.
   d. The 60-second time delay will start counting. If the abort switch is held closed, the release will be aborted. As soon as the abort button is released, the discharge delay countdown will restart at the preset duration.
   e. If no other action, the FM-200 will discharge after the time delay expires. Activation of a manual pull station will immediately release the FM-200.
   f. At discharge, the equipment power will shut down.

D. Operating manual-release stations will discharge extinguishing agent when activated.

E. Operating abort switches will delay extinguishing-agent discharge while being activated. Abort switch must be reset to prevent agent discharge. Release of switch will discharge agent.

F. Time Delays: Time delays should not exceed 30 seconds after the second confirming alarm initiates release of extinguishing agent. Time delays shall not recycle or reset.

1.4 SUBMITTALS

A. Product Data: Submit for the following equipment:
1. Extinguishing-agent containers.
2. Extinguishing agent.
3. Discharge nozzles.
4. Control panels.
5. Detection devices.
6. Manual-release stations.
7. Switches.
8. Alarm devices.
9. Audible/visual notification appliances.

B. Shop Drawings: The Contractor shall submit the following design information and drawings for acceptance prior to starting work on project:
1. Field investigation layout drawings having a scale of not less than ¼” = 1’-0” detailing the location of all agent storage tanks, pipe runs including pipe sizes and lengths, control panel(s), detectors, manual pull stations, abort stations, audible and visual alarms, and all mechanical, structural, and electrical interferences.
2. Auxiliary details and information such as maintenance panels, door holders, special sealing requirements, and equipment shutdowns.
3. Separate layouts or drawings for mechanical and electrical work.
4. Separate layout or drawings showing isometric details of agent storage containers, mounting details, and proposed pipe runs and sizes.
5. Electrical layout drawings shall show the location of all devices and include point-to-point conduit runs.
6. Provide copies of flow calculations from an industry recognized commercial program. Calculation sheets must include the manufacturer’s name for verification. The individual sections of pipe and each fitting to be used, as shown on isometric drawings, must be

identified and included in the calculations. Total agent discharge time must be shown and detailed by zone.

7. Submit drawings, calculations, and system component data sheets for approval by the City Engineer and Fire Marshall before starting construction.
8. Design/submittals shall comply with the requirements of NFPA 2001, Chapter 3.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain extinguishing agent and equipment through one source.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency and marked for intended use.

C. ASME Compliance: Fabricate piping to comply with ASME B31.1, "Power Piping."

D. FM Compliance: Provide components that are FM approved and are listed in FM's "Fire Protection Approval Guide."

E. NFPA Compliance: Fabricate and label clean-agent extinguishing systems to comply with NFPA 2001, "Clean Agent Extinguishing Systems."

F. UL Compliance: Provide equipment components that are UL listed for clean-agent extinguishing system units in UL's "Fire Protection Equipment Directory."

G. Contractor Qualifications: Contractor shall have the following qualifications.
   1. Be trained by the manufacturer to design, install, test, and maintain FM-200 fire suppression systems.
   2. Employ a NICET certified special hazard designer, Level 2, and Fire Alarm System Level 2, or above, who will be responsible for the project.
   3. A minimum of five years experience in the design, installation, and testing of FM-200 fire suppression systems.
   4. Have an FM-200 recharging station on the Contractor’s premises.
   5. Provide proof of ability to recharge the FM-200 system within 24 hours after a discharge and list the amount of FM-200 bulk storage available.
   6. Provide emergency services within 24 hours notification.

1.6 WARRANTY

A. All system components furnished and installed under this contract shall be guaranteed against defects in design, materials, and workmanship for the full warranty period which is standard for the manufacturer, but in no case less than one year from the date of systems acceptance.

B. The Contractor shall provide two inspections of the system(s) installed under this contract during the one year warranty period. The first inspection shall be at the six month interval and the second inspection at the twelfth month interval after system acceptance. Inspections shall be conducted in accordance with the manufacturer’s guidelines and comply with the recommendations in NFPA 2001.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Fike Corp.; Fire Protection Systems Div.
   2. Fenwal Protection Systems
   3. Amerex Corporation
   4. Or equal approved by the Authority Having Jurisdiction

2.2 PIPING MATERIALS

A. Piping, Valves, and Discharge Nozzles: Comply with types and standards listed in NFPA 2001, Section "Distribution," and Appendix A, for charging pressure of system.

B. Plain end couplings are not allowed on any piping systems.

2.3 VALVES

A. General: Brass; suitable for intended operation.

B. Container Valves: With rupture disc or solenoid, capable of immediate and total agent discharge and suitable for intended flow capacity.

C. Valves in Sections of Closed Piping and Manifolds: Fabricate to prevent entrapment of liquid, or install valve and separate pressure-relief device.

D. Valves in Manifolds: Check valve; installed to prevent loss of extinguishing agent when container is removed from manifold.

2.4 EXTINGUISHING-AGENT CONTAINERS

A. Description: Steel tanks complying with ASME Boiler and Pressure Vessel Code: Section VIII, for unfired pressure vessels. Include minimum working-pressure rating that matches system charging pressure, valve, pressure switch, and pressure gage.
   1. Finish: Manufacturer's standard color, enamel or epoxy paint.
   2. Manifold: Fabricate with valves, pressure switches, and connections for multiple storage containers, as indicated.
   3. Storage-Tank Brackets: Factory- or field-fabricated retaining brackets consisting of steel straps and channels; suitable for container support, maintenance, and tank refilling or replacement.

B. Each container shall have a pressure gauge and low pressure switch to provide visual and electrical supervision of the container pressure. The low pressure switch shall be wired to the control panel to provide audible and visual “Trouble” alarm in the event the container pressure drops below 272 psig. The pressure gauge shall be color coded to provide an easy visual indication of container pressure.

C. Each container shall have a pressure relief valve that automatically operates when the internal temperature exceeds 150 deg F.

D. Containers shall be actuated by parallel wired initiators located at each agent container.

2.5 FIRE-EXTINGUISHING CLEAN AGENT

A. Clean Agent: FM-200; HFC 227ea, heptafluoropropane.

2.6 DISCHARGE NOZZLES

A. Equipment manufacturer's standard one-piece brass or aluminum alloy of type, discharge pattern, and capacity required for application.

B. Nozzles shall be available in NPT pipe sizes ¼" through 2". Each size shall be available in 180 deg and 360 deg distribution patterns.

2.7 CONTROL PANELS

A. Description: FM approved or UL listed, including equipment and features required for testing, supervising, and operating fire-extinguishing system.

B. Power Requirements: 120-V ac; with electrical contacts for connection to system components and fire alarm system, and transformer or rectifier as needed to produce power at voltage required for accessories and alarm devices.

C. Enclosure: NEMA ICS 6, Type 1, enameled-steel cabinet.
   1. Mounting: Surface.
   2. Locks for all panels shall be keyed alike.

D. Supervised Circuits
   1. Provide the following detection applications:
      a. Single Zone detection circuit.
      b. Manual pull-station circuit.
      c. Alarm circuit.
      d. Release circuit.
   2. Provide the following control-panel features:
      a. Electrical contacts for shutting down fans, activating dampers, and operating system electrical devices.
      b. Automatic switchover to standby power at loss of primary power.
   3. Standby Power: Sealed lead-acid batteries with capacity to operate system for 72 hours and alarm for minimum of 15 minutes. Include automatic battery charger, with varying charging rate between trickle and high depending on battery voltage, that is capable of maintaining batteries fully charged.

2.8 DETECTION DEVICES

A. Description: Comply with NFPA 2001 and NFPA 72, and include the following types:
   1. Photoelectric Detectors: UL 268, consisting of LED light source and silicon photodiode receiving element.
   2. If included in the contract, a Fenwal AnaLASER air–sampling control panel may be utilize to activate the FM-200 fire suppression system control panel.

2.9 MANUAL-RELEASE STATIONS

A. Description: FM approved or UL listed, with "PULL STATION" caption 24-V dc compatible with controls, and red finish. Include contacts for connection to control panel. Unit can manually discharge extinguishing agent with operating device that remains engaged until unlocked.
   1. Mounting: Surface.

2.10 SWITCHES

A. Description: FM approved or UL listed, where available, 120-V ac or low voltage compatible with controls. Include contacts for connection to control panel.
   1. Abort Switches: Dead-man type, requiring constant pressure, for delay of system discharge.
      a. Abort switches do not repeat any time delays.
      b. Abort switches are located within the protected area near the exit.

2.11 ALARM DEVICES

A. Description: FM approved or UL listed, where available, 120-V ac or low voltage compatible with controls. Include contacts for connection to control panel.

B. Horns: 90 to 94 dBA.

C. Strobe Lights: Translucent lens, with "FIRE" or similar caption as directed by Owner.

2.12 ELECTRICAL POWER AND WIRING

A. Electrical power, wiring, and devices are specified in Section 16001, “Electrical Work”.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with City Engineer present, for compliance with hazard-area leakage requirements, installation tolerances, and other conditions affecting work performance.

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

3.2 CLEAN-AGENT EXTINGUISHING PIPING INSTALLATION

A. Install clean-agent extinguishing piping and other components level and plumb and according to manufacturers' written instructions.

B. Grooved Piping Joints: Groove pipe ends according to AWWA C606 dimensions. Assemble grooved-end steel pipe and steel, grooved-end fittings with steel, keyed couplings and lubricant according to manufacturer's written instructions.

C. Install extinguishing-agent containers anchored to substrate.

D. Install pipe and fittings, valves, and discharge nozzles according to requirements listed in NFPA 2001, Section "Distribution," and related Appendix A paragraphs; and ASME B31.1.
   1. Install valves designed to prevent entrapment of liquid or install pressure-relief devices in valved sections of piping systems.
   2. Install control panels, detection system components, alarms, and accessories, complying with requirements of NFPA 2001, Section "Detection, Actuation, and Control Systems," as required for supervised system application.

E. All piping shall be reamed, blown clear, and swabbed with suitable solvents to remove burrs, mill varnish, and cutting oils before assembly.

F. All male threads shall be sealed with Teflon tape pipe sealant applied before assembly.

3.3 LABELING

A. Caution/Advisory Signs: Provide labeling on entrances, piping, extinguishing-agent containers, other equipment, and panels according to NFPA 2001, including:
   1. Entrance sign at entrance to protected space.
   2. Manual Discharge sign at manual discharge station.
   3. Flashing Light sign required at each flashing light over exit from protected space.

3.4 WIRING

A. System components shall be securely supported independent of the wiring. Runs of conduit and wiring shall be straight, neatly arranged, properly supported, and installed parallel and perpendicular to walls and partitions.

B. The sizes of conductors shall be those specified by the system manufacturer. Color codes shall be used. All wires shall be free from grounds and crosses between conductors.

C. Install wiring to conform to the National Electric Code for Class 1 Signal Systems, except as otherwise permitted for limited energy circuits, as described in NFPA 72.

D. The complete system electrical installation, and all auxiliary components, shall be grounded in accordance with NFPA 70.

3.5 TRAINING REQUIREMENTS

A. Prior to acceptance, provide operational training and materials on the system to the owners of the protected space and other personnel designated by the SNL Fire Protection Engineer.

B. Training session shall include system control panel operation, manual and abort functions, trouble procedures, auxiliary functions, and emergency procedures.

3.6 OPERATION AND MAINTENANCE

A. Prior to final acceptance, provide four copies of a complete operation and maintenance manual to the City Engineer. The manual shall include the following:

1. All aspects of system operation and maintenance detailed, including piping isometrics, wiring diagrams of all circuits, a written description of system design and sequence of operation.
2. Drawing(s) illustrating control logic.
3. Equipment used in the fire suppression system.
4. Checklists and procedures for emergency situations.
5. Troubleshooting techniques.
6. Maintenance operations and procedures.

3.7 AS-BUILT DRAWINGS

A. Provide four copies of system “as-built” drawings to the City Engineer. Drawings shall include:
   1. Actual equipment locations (control panels, agent containers, detectors, alarms, manual and abort switches).
   2. Piping and conduit routing details.
   3. ll room or facilities modifications.

3.8 SYSTEM INSPECTION AND CHECKOUT

A. After system installation is completed, the entire system shall be checked out, inspected, and functionally tested by qualified, trained personnel, in accordance with the manufacturer’s recommended procedures and NFPA 2001, Section “Approval of Installations”.

B. All containers and distribution piping shall be tested for proper mounting and installation. Perform a “puff test” by discharging a sufficient flow of nitrogen through the piping to verify integrity of piping installation.

C. All electrical wiring shall be tested for proper connection, continuity, and resistance to ground.

D. The complete system shall be functionally tested in the presence of the City Engineer and Authority Having Jurisdiction (AHJ) Fire Marshall.

E. All functions, including system and equipment interlocks, must be operational at least five days prior to the final acceptance tests.

F. Remove all keys from manual pull stations, control panels, and all other key-operated devices when FM-200 agent becomes operational. Deliver keys to City Engineer

G. Verify all manual pull stations are in the securely closed position to prevent an inadvertent FM-200 release.

3.9 ACCEPTANCE TESTING

A. Conduct acceptance tests in the presence of the City Engineer and Fire Marshall

B. The acceptance test shall include the following:
   1. The entire control system shall be tested to determine it functions as designed and intended. All circuits shall be tested, including.
      a. Automatic actuation
      b. Manual actuation
      c. HVAC and power shutdowns

d. Audible and visual alarm devices
e. Manual override of abort functions
f. Smoke/fire damper operation
g. Agent container pressure supervision

2. Supervision of all panel circuits, including AC power and battery power supplies, shall be tested and qualified.
3. Conduct a room pressurization test for each protected space to determine the presence of openings that would impact FM-200 system concentration levels during an activation. Testing shall be conducted in accordance with NFPA 2001 requirements.
   a. If openings are discovered, the Contractor shall be responsible for coordinating the proper sealing of the protected space(s) by the Authority Having Jurisdiction (AHJ).
   b. Upon completion of repairs, the Contractor shall conduct additional room pressurization tests until a successful test is obtained.
   c. Copies of successful test results shall be submitted to the City Engineer and Fire Marshall

END OF SECTION

22 05 00

PLUMBING GENERAL PROVISIONS

PART 1 GENERAL

1.1 SCOPE

A. The intent of the guide specification is to provide direction to design professionals and contractors to specific levels of quality, expected practices and material selection. The design professional shall use this guide in conjunction with complete project technical specification prepared for each specific project by the design professional to meet the specific needs of each individual project.

B. Variations from products, methods, and materials anticipated as part of a specific project requirement should be brought to the attention of the Owner's project manager during the design process for review, comment and approval.

1.2 WORK AND MATERIALS

A. Unless otherwise specified, all materials must be new and of the quality specified. The workmanship shall be of a quality that is acceptable to the Architect/Engineer and is equal to the standards of the trades.

B. Uniformity: Unless otherwise specified, provide all equipment and products of same type or classification by the same manufacturer.

C. Repair any fire protection removed or damaged by work in this Section in accordance with Section 07 81 00

1.3 OPERATION AND MAINTENANCE MANUAL

A. Manuals shall be tabulated, indexed and bound in a three-ring binder. A preliminary submittal of the manual shall be made to the Architect 90 days after receiving approved submittals. Final submittal of the manual shall be made four weeks prior to substantial completion of the project. One hard copy and one electronic copy of the operation and maintenance manual shall be provided as part of the project closeout.

1.4 SHOP DRAWINGS

A. Contractor shall provide all shop drawings and wiring diagrams complete with all connection details. Wiring diagrams shall not contain optional methods that do not apply. Wiring diagrams must be complete with all necessary information and must correctly indicate the conditions of this specific job.

B. Equipment layouts, drawn to a scale of 1/2" = 1'-0", including equipment piping and accessories, showing clearances for operating and servicing.

1.5 IDENTIFICATION

A. Equipment: Equipment shall be identified with engraved plates made of 3/32" thick laminated black Bakelite with white core. Engrave to produce 3/8" high white lettering on black background. Engraved plates shall be screwed on. The identification shall correspond to the designation used on construction drawings and shall include, but not be limited to, the following: pumps, boilers, water heaters, water softeners, etc.

B. Valves:

1. Carefully prepare chart or diagram for each piping system, indicating by number each valve in the system and each valve's location and function. Numbers used on valves shall correspond with chart.

2. Mount one of each chart in every mechanical equipment room applicable. Mount each chart in aluminum frame with clear glass front and secure to wall where directed.

3. Bind a copy of each chart in maintenance manuals.

4. Provide each valve with a brass or aluminum disc not less than 1-1/4" diameter and bearing 3/8" high, engraved numbers corresponding to those shown on chart. Fasten tag to valve with #14 brass wire.

C. Pipe:

1. Mark each individual pipe with Brady, Seton, Brimar, or Set Mark identification markers with flow arrows of snap-on type after pipe has been painted or insulated.

2. Install stencils at all major branch takeoffs, risers and at 10-foot intervals on straight runs and at each entrance or exit from pipe shafts. Markers shall be located for maximum visibility from expected personnel approach.

3. Identification material sizes shall be as follows:

a. 2" and Under: 1/2" high letters.

b. Over 2": 1" high letters.

Provide a typewritten schedule of all markers used, with identification framed under glass and posted in the Mechanical Equipment Room.

4. Identify pipe with following:

Service	Abbreviation
Domestic Cold Water	CW
Domestic Hot Water	HW
Domestic 140º Hot Water	HW (140º)
Domestic Hot Water Return	HWR
Vent	V
Storm Drains	SD
Process Water	Process*
Diesel Fuel	DIESEL

*Process water piping shall be identified per all applicable sections of the plumbing code and all process water termination points shall be identified per code.

5. Pipe markers for piping not listed above shall conform to the latest ANSI and OSHA requirements.

1.6 GUARANTEE

A. Guarantee all material, equipment, installation and workmanship for all sections under Division 22 in writing to be free from defects of material and workmanship for one year from date of final acceptance as outlined in Division 01. Equipment warranties shall be a minimum of one year from date of substantial completion or as specified elsewhere.

PART 2 DESIGN STANDARD

2.1 ACCESSIBILITY

A. Install valves, thermometers, gauges, traps, cleanouts, control devices or other specialties requiring reading, adjustment, inspection, repairs, removal or replacement conveniently and accessibly throughout the finished building. Where any of these devices are shown on the contract drawings to be installed above any inaccessible ceiling or behind any inaccessible wall, the Contractor shall furnish access doors or panels as required.

B. All access doors or panels in walls and ceilings required for access to control devices, traps, valves and similar devices are to be furnished and installed as part of the work under this section. Provide type as specified under Division 08.

2.2 PRODUCT AND EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. All equipment, valves, sensors, etc., shall be installed in strict conformance with the manufacturer’s recommendations and all codes.

B. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

D. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations.

E. Install equipment to allow right-of-way for piping installed at required slope.

F. Do not install any equipment in an application not recommended by the manufacturer.

END OF SECTION

22 05 01

SUMMARY OF WORK FOR PLUMBING

PART 1 GENERAL

1.1 ALTERNATE EQUIPMENT

A. Specification of all equipment and materials in Division 22 by brand name is intended to establish a standard of quality.

B. Submittal of equipment by other acceptable manufacturers must be made in advance to Facilities Engineering during the design process.

C. Approved Plumbing Equipment Manufacturers: Following is a list of manufacturers whose equipment is acceptable as to manufacture, subject to conformance with all drawings, specifications, and addenda items.

Access Doors: Zurn, Josam, J.R. Smith, Wade.

Acid Waste Piping and Fittings (Glass): Schott / Kimax.

Acid Waste Piping and Fittings (Polypropylene): Orion, IPEX, Enfield, Zurn.

Air Compressor: Gardner Denver, Ingersoll-Rand, Champion.

Automatic Flow Control Valves: Griswold, Aquaduct, Flow Design, Wilkins, Nexus.

Automated Plumbing System: Icon, Sloan

Backflow Preventer: Watts, Conbraco, Wilkins.

Booster Pumps: Grundfus, Bell & Gossett, Armstrong.

Circulating Pumps: Bell & Gossett, Armstrong, Taco

Cleanouts: Zurn, J.R. Smith, Wade, Josam, Mikro, Watts.

Closed Cell Insulation: Halstead-Nomalco, Armstrong, Rubatex.

Closet Seats: Sperzel, Church, Olsonite, Beneke, Bemis, Zurn.

Dilution Tanks: Orion, IPEX, Enfield, Zurn.

Domestic Water Boilers: Teledyne Laars, Lochinvar, Raypak, Precision, A.O. Smith, PVI.

Domestic Water Heaters: Lochinvar, Rheem, PVI, A.O. Smith, Bock, Bradford White.

Electric Water Coolers: Elkay, Halsey Taylor, Haws, Oasis, Bradford White.

Expansion Tanks: Conbraco, Therm-X-Trol, Watts.

Eye Wash/Emergency Shower: Bradley, Acorn, Haws.

Floor Drains and Floor Sinks: Zurn, J.R. Smith, Wade, Josam, Watts, Sioux Chief.

Flues: Selkirk Metalbestos, Merivent, Metal-Fab.

Flue Vent Caps: Ameri-Cap, Metal-Fab, Dura-Vent, Selkirk Metalbestos.

Flush Valves: Sloan, Zurn.

Gas Pressure Regulator: Rockwell, Sensus.

Handicap Supplies and Waste Insulation: Prowrap, Truebro, McGuire, Zurn.

Hose Bibbs / Wall Hydrants: Chicago, Acorn, Woodford, J.R. Smith, Watts, Zurn.

Mixing Valves: Symmons, Powers, Leonard, Bradley.

Mop Sinks: Fiat, Florestone, Zurn, Acorn.

Pipe and Equipment Insulation: Owens-Corning, CertainTeed, Manville, Pittsburgh, Armstrong, Knauf.

Pipe Hangers & Supports: Elcen, Grinnell, Amber-Booth, Kin-Line, Power Strut, Unistrut, F&S, Piping Technology & Products, B-Line Systems, Michigan Hanger Co., National Pipe Hanger Corp., PHD Manufacturing, PHS Industries, Pipe Shields Inc., Sioux Chief.

Pipe Shields: Pipe Shield Incorporated.

Plumbing Fixtures: American Standard, Crane, Kohler, Eljer, Zurn, Icon.

Plumbing Supply Fittings: Dahl ¼, Chicago, Symmons, Delta Commercial, T & S, Moen, Zurn, Sloan, Speakman.

Plumbing Supply Stops: Dahl ¼ turn, Eastman, Crane, Kohler, Eljer, Wolverine, Brasscraft, Zurn.

Pre-Cast Interceptors, Manholes, Septic Tanks, Catch Basins: Pre-Cast Manufacturing, Smith Pre-Cast, Super Products.

Pressure Gauges: Weksler, Trerice, Ashcroft (liquefied), Palmer, Marsh, Weiss.

Pressure Reducing Valve: Watts, Wilkins, Conbraco.

P-Traps and Continuous Waste Assemblies: Brasscraft, Dearborn, Zurn, Crane, Kohler, Eljer, McGuire,.

Roof Drains and Overflows: J.R. Smith, Sloan, Josam, Wade.

RO/DI Systems: G.E. Water, Siemens, High Peaks, WTT.

Security Fixtures: Acorn, Bradley, Willoughby.

Sewage Ejectors: Gould, Weil.

Shock Absorbers: Zurn, J.R. Smith, Wade, Josam, PPP, Watts, Sioux Chief.

Shower Valves: Chicago, Powers, Symmons, Leonard, Acorn, Zurn, Bradley, Icon.

Stainless Steel Sinks: Elkay, Just, Moen.

Storage Tanks: Teledyne Laars, Lochinvar, Raypak, A.O. Smith.

Storm Drainage Pipe Heavy-Duty No-Hub Clamps: AB&I, Clamp-All 125, Husky SD 4000, Tyler wide body.

Sump Pumps: Gould, Weil, Hydromatic.

Thermometers: Weksler, Trerice, Ashcroft, Palmer, Taylor, Weiss.

Trap Primers: PPP, Sioux Chief.

Trap Seal: Trap Guard by Proset Systems.

Trench Drains: Zurn, Polydrain.

Valves: Apollo, Watts, Milwaukee (ball check), Nibco, Hammond.

Valves (Ball Check): Flygt, Flomatic.

Wash Fountains: Bradley, Acorn, Willoughby.

Waste Pipe Heavy-Duty No-Hub Clamps (Below Grade): Clamp-All, Husky, Tyler wide body, Mission.

Waste Pipe No-Hub Clamps (Above Grade): Husky, Tyler, Mission, Clamp-All.

Water Softeners: Ecodyne, Watertec, Marlo, High Peaks.

END OF SECTION

22 05 10

BASIC PIPING METHODS

PART 1 GENERAL

1.1 SUMMARY

A. This section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric protection.
4. Sleeves.
5. Escutcheons.

1.2 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

PART 2 DESIGN STANDARD

2.1 DIELECTRIC PROTECTION

A. Provide dielectric provisions at all points where copper or brass pipe or equipment is joined to ferrous pipe and equipment as follows:

1. For threaded x threaded connections, sizes 1/2" through 4", Victaulic CLEARFLOW waterway connector.

2. For threaded x grooved connections, sizes 1" through 4", Victaulic CLEARFLOW waterway connector.

3. For copper to steel flange connections, sizes 1-1/2" through 8", CTS copper flange adapter.

B. Dielectric insulating unions will be accepted per Code.

C. This requirement does not apply to brass valves in steel lines or joints between copper and cast iron drainage lines.

2.2 SLEEVES

A. Steel Pipe: ASTM A 53, Type E, Grade B, schedule 40, galvanized, plain ends.

B. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With setscrew and polished chrome-plated finish.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw and polished chrome-plated finish.

E. One-Piece, Floor-Plate Type: Cast-iron floor plate.

F. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.4 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping in concealed locations or areas with exposed structure except in equipment rooms and service areas.

B. Install all piping at right angles or parallel to building walls. Diagonal runs are prohibited unless approved by owner.

C. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

D. Install piping to permit valve servicing.

E. Uniformly grade all horizontal piping to provide for service drainage and air escapement. Where conditions do not permit constant pitch, establish intermediate low or high point, drop or rise to new level, and provide drain and air vent as required. Pitch pipes a minimum of 1 inch per 40 feet, in direction of flow, unless otherwise indicated or specified.

F. Do not locate piping in electrical equipment rooms unless it serves that room. Do not locate it directly above electrical equipment in any room. Where piping is located in an electrical equipment room which it serves, provide a 20 gauge galvanized sheet metal drip pan with drain line to floor drain.

G. Install escutcheons for penetrations of walls, ceilings, and floors according to the

following:

1. Piping:

   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.

   b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.

   c. Insulated Piping: One-piece, cast-brass type with polished chrome-plated finish.

   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.

   e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.

   f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.

H. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, used for fire, smoke or sound control, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

   a. Steel Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).

   b. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Seal space outside of sleeve fittings with grout. Refer to Division 07.

3. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07.

I. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using schedule

40 PVC sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

J. Underground, Exterior-Wall Pipe Penetrations: Install schedule 40 PVC sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

END OF SECTION

22 05 13

ELECTRIC MOTORS

PART 1 GENERAL

1.1 SUMMARY

A. Provide premium efficiency motors for all pumps of 1 HP and larger size.

PART 2 DESIGN STANDARD

2.1 ELECTRICAL MOTORS

A. General:
1. Motors 3/4 HP and larger except as otherwise noted shall be designed for 3 phase, 60 hertz power supply.
2. Motors 1/2 HP and smaller, except as otherwise noted, shall be designed for 120 volt, single phase, 60 hertz power supply.
3. Motors connected to variable frequency drives shall be inverter duty rated.
4. Motors shall be approved by Underwriters' Laboratories (UL) for the service specified with a minimum service factor of 1.15.

B. Motor Efficiency: Motor efficiencies shall be as mandated by ASHRAE 90.1 or IECC editions acceptable to the local authority having jurisdiction.

2.2 MOTOR CONTROLLERS

A. Furnish motor controllers as specified herein.

1. For single phase motors without internal overload protection and three phase motors, provide starters as specified in this section.

2. For single-phase motors with internal overload protection, provide starters as above or definite purpose contactors per below.

B. Starters shall be Square D Class 8536 or equivalent. Starters shall be NEMA devices. IEC starters and NEMA rated IEC starters are not acceptable.

C. Non-reversing starter units shall consist of a full voltage magnetic starter providing external manual reset, thermal overload and low voltage protection. Each starter shall be equipped with indicating lights, auxiliary contacts, HOA’s, control transformers, etc., as required for proper operation by the control system. (All starters shall be furnished with overloads in each phase leg, of size to be selected after final installed nameplate full load amperes of motors is determined.)

D. Starters to be installed indoors shall be provided in NEMA Type 1 enclosure.

E. Starters to be installed outside shall be provided in NEMA Type 4 enclosure.

F. Controllers for equipment containing single phase motors with internal motor overload protection shall be allowed to be controlled by a NEMA Class Definite Purpose Contactor rated for the full load amperes of the motor. Contactors shall be Square D Company Type DPA, Class 8910, or equivalent by General Electric or Cutler-Hammer.

END OF SECTION

22 05 23

VALVES

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. Valves shall be utilized on main branches from Risers, at main taps from main horizontal runs. In taps to plumbing groups, at inlet and outlet of all equipment, on runouts to exterior hose bibbs and as needed to prevent shutdown of significant portions of the building for repairs, service or expansion.

1.2 QUALITY ASSURANCE

A. Valve Types: All valves shall be of the same manufacturer unless otherwise specified.

PART 2 DESIGN STANDARD

2.1 GENERAL

A. All valves shall be supplied with stamped brass identification tags supplied by the contractor. All valve ports shall be full size same size as connected piping. Install valves on all hot and cold branch lines. Provide access panel at valves locations.

2.2 DOMESTIC HOT AND COLD WATER SERVICE

A. Valves 2" and Smaller:

1. Ball Valves: Valves shall be rated 150 PSI SWP and 600 PSI non-shock WOG and will have two-piece cast bronze bodies, TFE seats, full port, separate packnut with adjustable stem packing, anti-blowout stems, 316 stainless steel trim and 316 stainless steel ball. Valve ends shall have full depth ANSI threads or extended solder connections and be manufactured to comply with MSS-SP110.

a. Acceptable Valves, Full Port: NIBCO T-585-70-66 or Hammond 8901/8503/8301 (threaded); NIBCO S-585-70-66 or Hammond 8911/8513/8311 (solder).

b. NOTE: Where piping is insulated, ball valves shall be equipped with 2" extended handles of non-thermal conductive material. Also, provide a protective sleeve that allows operation of the valve without breaking the vapor seal or disturbing the insulation. Memory stops, which are fully adjustable after insulation is applied, shall be included.

B. Valves 2-1/2" and Larger:

1. Gate Valves: Valves to be Class 125, malleable iron hand wheel, rising stem, flanged, bolted bonnet, OS&Y, bronze body, bronze trimmed, with body and bonnet conforming to ASTM standards. Packing and gaskets to be non-asbestos.

C. Check Valves:

1. Check valves 2-1/2" and smaller shall be Y-pattern swing-type manufactured in accordance with MSS-SP80, Class 125, bronze ASTM B-62 body with TFE seat disc. Where higher operating pressures approach 150 PSI, Class 150 valves of like construction shall be used. Valve ends may be threaded or solder-type.

a. Acceptable Valves - Horizontal Installation:

1) Class 125: NIBCO T-413-Y or Hammond IB904 (threaded); NIBCO S-413-Y or Hammond IB912 (solder).

2) Class 150: NIBCO T-433-Y or Hammond IB946 (threaded); NIBCO S-433-Y or Hammond IB945 (solder).

b. Acceptable Valves - Vertical and Horizontal Installation:

1) Class 125: NIBCO T-480-Y or Hammond 943 (threaded).

2. Check valves 2-1/2" and larger shall either be swing-type, Class 125, flanged bronze body with bronze trim, non-asbestos gasket, or wafer style with stainless steel spring, bronze disc plates, rubber seat, body of bronze for use with Class 125/150 flanges. Spring-actuated valve to be used on pump discharge. Wing check with outside lever and spring to be used on storm drain lines. Sump pump and sewage ejector discharge shall be ball or swing type check valve.

a. Acceptable Valve Manufacturers:

1) NIBCO or Hammond

D. Valve Actuators:

1. On valves specified to be provided with actuators furnish compact electric actuators, 115VAC.

END OF SECTION

22 05 29

HANGERS AND SUPPORTS

PART 1 GENERAL

1.1 SUMMARY

A. This section includes hangers and supports for piping systems and equipment.

B. Piping 2-1/2" and Smaller: Use adjustable, split ring malleable iron type or adjustable steel clevis type with threaded solid steel hanger rods.

C. Piping 3" and Larger: Use adjustable steel clevis type hangers with threaded solid steel hanger rods.

D. Size all hangers on insulated piping to fit outside covering.

E. When supporting copper pipe with steel hangers provide hard insulation between the pipe and the support to prevent a dielectric connection. See Insulation section for more information.

F. Hanger Rod Sizes:

Pipe Size	Rod Diameter (Inches)
2" and smaller	3/8
2-1/2" and 3"	1/2
4" and 5"	5/8
6"	3/4
8" through 14"	7/8

G. Hanger Rod Spacing (Horizontal Piping):

Pipe	Max. Hanger Spacing (Ft. O.C.)
Steel pipe 3/4" and smaller	6
Steel pipe 1"	8
Steel pipe 1-1/4" through 12"	10
Copper tubing 1-1/4" and smaller	6
Copper tubing 1-1/2" and larger	8
Special piping materials	As recommended by manufacturer

PART 2 DESIGN STANDARD

2.1 HANGER AND SUPPORT APPLICATIONS

A. Horizontal-Piping Hangers and Supports:

1. Adjustable Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated stationary pipes, NPS 1/2 to NPS 30.

B. Vertical-Piping Clamps:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.

2.2 HANGER AND SUPPORT INSTALLATION

A. Provide hangers at all offsets, tees, within 12" of all horizontal elbows, and elsewhere as herein described.

B. Sleeve and seal air and watertight all piping passing through exterior walls, through plenum or fire walls above ceilings. All sealers shall be waterproof and fireproof.

C. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping, using thermal-hanger shield insert with clamp, sized to match OD of insert. Do not exceed pipe stress limits.

2. Thermal-hanger shield inserts shall be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Shield Dimensions for Pipe: Not less than the following:

a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.

b. NPS 4: 12 inches long and 0.06 inch thick.

END OF SECTION

22 07 00

PIPING INSULATION FOR PLUMBING

PART 1 GENERAL

1.1 SCOPE

A. Apply insulation after piping has been installed, tested, approved, dry, and in a clean condition. Insulate all cold, hot, hot return, and condensate piping completely.

PART 2 DESIGN STANDARD

2.1 MATERIAL

A. Pre-molded closed cell insulation, maximum K factor per plans. Insulation shall have vapor sealed seams, PVC jacket with white finish, and pre-molded fitted clam shell covers for all valves, fittings, and devices.

2.2 APPLICATION

A. Piping: Insulation end joints to be tightly butted together with butt joint strips and the longitudinal seam sealed closed. Where possible, locate all longitudinal seams out of sight. Cover building interior pipe insulation with PVC jacket. PVC jacket shall have a flame spread of not more than 25 and a smoke development of not more than 50. Cover building exterior pipe insulation with all-weather embossed aluminum jacket .024” min thickness, sealed with silicone, and band tied with stainless steel bands 18” on center.

B. Valves, Fittings and Flanges (Concealed): Insulate all concealed valves, fittings, ptraps, and flanges with pre-molded sectional covering.

C. Valves, Fittings and Flanges (Exposed): Insulate all exposed valves, fittings and flanges as specified for concealed fittings, and cover with PVC jacket. PVC jacket shall have a flame spread of not more than 25 and a smoke development of not more than 50. Cover building exterior pipe insulation with all-weather embossed aluminum jacket .024” min thickness, sealed with silicone, and band tied with stainless steel bands 18” on center. Valve and device covers shall be tight fitted to the devices they cover.

D. Hangers, Rollers and Rigid Inserts under Supports: Provide a protective shield covering of 18-gauge galvanized steel placed centrally at all hangers and rollers. Shield shall cover half of the insulation and have a length of not less than 12". Insert a 12" section of calcium silicate or similar rigid product for this application pre-approved and acceptable to the engineer at each hanger and roller location.

E. Notching installation at supports will not be permitted. Crushed insulation at supports will be repaired by contractor when detected at any stage of

construction. Cost of repair shall be borne by the contractor.

2.3 INSULATION THICKNESS

A. Insulation wall thickness shall conform to the following schedule:

1. All piping:

a. 1” thickness minimum

2. Domestic Cold Water Lines: Insulate all cold water piping outside the building insulation with 1" thick insulation and vapor barrier.

2.4 HANDICAP FIXTURE INSULATION

A. Insulate hot water, cold water and drain piping under wheelchair lavatories and sinks with Truebro Handi Lav-Guard insulation kits. Insulation shall be nominal 3/16" wall thickness and tested in accordance with the procedures outlined in ASTM Test Method C-177.

END OF SECTION

22 11 16

DOMESTIC WATER SYSTEM

PART 1 GENERAL

1.1 SUMMARY

A. Install all piping above floor unless physically impossible to do so.

PART 2 DESIGN STANDARD

2.1 PIPING

A. Type "L" hard drawn copper, conforming to ASTM B88, for all water pipe not set in or under concrete or in the ground.

B. Type "K" hard drawn copper, conforming to ASTM B88, for water pipe set in the ground but not under concrete floor slabs.

C. Type "K" soft drawn copper, conforming to ASTM B88, for all water pipe set below concrete floor slab, install no joints below floor slab.

D. Color identify all copper piping with size of pipe, manufacturer's trademark, and conform to the following schedule:

Type "K" Copper ..... Green
Type "L" Copper ..... Blue

2.2 FITTINGS

A. Provide wrought copper solder (lead free) type fittings conforming to ANSI B16.22 (1963) for all connections to copper piping. Tube drawing is not approved.

2.3 SOLDER

A. Lines 1/2" Through 2": Use Lead Free 95/5 or Lead Free Silvabrite 100 coppermate solder with suitable flux, except on ball valves.

B. Lines 2-1/2" and Larger: Use Sil-Fos, Aircosil 45, or other silver brazing alloy of equivalent melting point and physical properties. Use Aircosil flux or equal suitable to brazing alloy.

2.4 INSTALLATION

A. Install full port ball valves on all water lines.

B. Pitch water piping to drain and install all necessary drain valves.

C. Bury all underground water piping a minimum of 18" below finish grade.

D. Copper pipe installed below concrete floor or ground in soil shall be without joints and shall be wrapped with 20 mil polyethylene tape with a minimum of 50% overlap or shall be installed in a 20 mil polyethylene sleeve.

END OF SECTION

22 11 19

PLUMBING SPECIALTIES

PART 1 GENERAL

1.1 SCOPE

A. This section describes miscellaneous materials and equipment necessary for the plumbing systems hereinbefore described.

PART 2 DESIGN STANDARD

2.1 PIPE HANGERS AND SUPPORTS

A. Adequately support piping against sagging, pocketing, swaying and displacement. Properly space and apply hangers to achieve the result, and not farther apart than the following:

Steel Pipe	Maximum Hanger Spacing	Rod Diameter
3/4" and smaller	8 feet on center	3/8"
1-1/4" through 2"	10 feet on center	3/8"
2-1/2" through 4"	12 feet on center	1/2"
6" through 8"	12 feet on center	3/4"
Copper Tubing		
1-1/2" and smaller	6 feet on center	3/8"
2" and 2-1/2"	10 feet on center	3/8"
3" through 4"	10 feet on center	1/2"
5" through 8"	10 feet on center	3/4"
Cast Iron Pipe		
	5 feet on center and all branches in excess of 30" long	

B. Use Kin-Line #450 or equal pipe hangers where trapeze hangers are used, space for the smallest pipe in the group from the schedule above.

C. Piping Supported from Walls: Hang from hangers hung from Kin-Line #519 or equal angle wall bracket.

D. Install Kin-Line #450 or equal pipe hangers with fixed felt liner around outside all uninsulated copper lines (Trisolator or equal).

E. Size all hangers on insulated lines to fit around outside diameter of insulation specified with allowance for Kin-Line #460 or equal, 22 gauge galvanized sheet metal shield.

2.2 CLEANOUTS

A. Interior Finished Floors or Sidewalks:

1. Concrete and Tile Floors: Zurn ZN1400-BP with scoriated nickel-bronze top.

2. Terrazzo Floors: Zurn ZN1400-BP-Z with satin nikaloy top.

B. Interior Finished Walls: Zurn Z1446-BP cleanout tee with wall access cover and bronze threaded or ABS plugs.

C. Outside Yard Cleanouts: Zurn Z-1474 with 12" x 12" poured concrete pad at grade.

D. NOTE: Provide all cleanouts with threaded bronze or ABS plugs.

2.3 DRAINS

A. General: All drains shall meet ANSI Standards. Provide cast iron body drains with lacquer finish. Where installed in surfaces having waterproofing membrane, provide drains with non-puncturing, flashing clamp device and anchoring flange. Drains not receiving a continuous flow of water shall be connected to a drain line from a trap primer.

B. Floor Drains:

1. Toilet Rooms and Finished Areas: Zurn ZN415-S-P with type S strainer and trap primer connection.
2. Floors must slope to drain. Drain shall be below grade.

C. Floor Sinks:

1. Building: enameled floor sink with bottom dome strainer and with type of grate called for on the kitchen drawings.

2. Finished Areas:

a. Zurn Z-1750–P-Y all stainless steel floor sink with mesh basket. Provide trap primer connection.

b. Enameled floor sink with bottom dome strainer and with type of grate called for on drawings. Provide trap primer connection.

D. Fixed Air Gap: Zurn Z-1025, cast iron. Provide with trap primer connection and access panel.

2.4 FIXTURE SUPPORTS

A. Water Closets:

1. General: Provide adjustable cast iron fixture supports for all wall hung water closets, except where single vertical carriers in shallow walls occur. Secure carrier foot supports to floor with 1/2" anchor bolts and 1/2" Phillips expansion shields drilled into concrete slab. Carriers shall be rated for 500 lb minimum.

2. Wall Hung Siphon Jet Water Closets: horizontal or vertical, adjustable, shallow rough-in support. Where furred space is not sufficient for the adjustable series, use "compact" .

B. Urinals - Wall Hanger or Urinals Supported on Steel Studding: To be securely attached to 1/4" thick by 6" wide steel wall plate extending at least one stud beyond fixture mounting point, welded to each stud it passes. Use 1/8" fillet weld across the full width of the steel stud flange, or bolt on by use of not less than two 1/4" "U" bolts per stud.

C. Fixtures Supported on Masonry Walls: Support fixtures secured to concrete or masonry walls with 5/16" bolts into "tamp-in" type anchors or two-unit cinch anchors.

2.5 HOSE BIBBS & WALL HYDRANTS

A. Woodford Model #65 (Frostproof), 3/4" recessed wall hydrant with loose key, vacuum breaker, in cast brass enclosure with hinged door. Exposed parts are to be polished brass.

2.6 SHOCK ABSORBERS

A. Watts or Zurn Series. Provide dielectric bushings at connection to piping system. Provide stainless steel access door as required for removal and access. Must be PDI listed. Provide mechanical shock absorber at all groups or single fixtures using flush valves or any quick-closing type of valve device. Install in a location as directed by manufacturer's recommendations.

2.7 TRAP PRIMERS/ TRAP VENT PROTECTION

A. Provide electrically actuated trap primers. Provide stainless steel access door for trap primers in walls. Must be PDI listed. Trap primers require an accessible shut off valve with union.

2.8 PRESSURE REDUCING VALVES

A. Valve construction shall be leakproof in the event of failure of any internal parts, and valve shall be accessible for replacement of parts.

B. Valves shall have capabilities of supplying water at the capacity rate specified with not over 10-pound reduced pressure change from a no-flow demand to maximum flow demand condition.

C. Approved valves shall comply with all applicable materials and construction requirements of ASSE Standard No. 1003, Water Pressure Regulating Valves for Domestic Water Supply Systems.

2.9 THERMOSTATIC MIXING VALVE

A. Master water mixing valve shall be of the thermostatic type. It shall have bronze body with replaceable corrosion resistant components. Valve shall come equipped with union end stop and check inlets with removable stainless steel strainers. Valve shall provide protection against hot or cold supply line failure and thermostat failure.

B. Provide shutoff on hot, cold and tempered water lines and provide a thermometer in the discharge line.

C. Mixing valves on eye was stations should fail to cold.

2.10 BACKFLOW PREVENTERS

A. Reduced Pressure Backflow Preventer: Febco or Watts Series 909S for sizes up to 2" or Series 909-NRSS for sizes 2-1/2" and larger, complete assembly including full port, resilient seated, bronze body test cocks and shutoff valves, Celcon check seats, stainless steel relief valve seats, shafts and flange bolts, tight-seating rubber check valve and relief valve assemblies, and inlet strainer with emergency repair kit.

B. Furnish and install air gap drain fitting and pipe to nearest floor sink when installed inside building.

C. Double Check Backflow Preventer: Watts Series 709DCDA-OSY-RW complete assembly, including full port, resilient seated, UL/FM OSY gate valves with epoxy coating, two positive seating, center guided, poppet type check valves, cast iron construction epoxy coated and emergency repair kit.

D. All backflow prevention devices shall comply with all applicable materials and construction requirements of ASSE, AWWA, CSA, IAPMO, and FCCCHR of USC standards.

2.11 Not Used

2.12 CONDENSATE DRAIN, EQUIPMENT OVERFLOW DRAINS, AND INDIRECT DRAIN PIPING SYSTEMS

Piping shall be copper type "DWV" copper tubing. Insulate copper tubing and P-trap from cooling coil connections using tight fitting closed cell insulation pre-formed to condensate drain piping and piping fittings. Fittings shall be wrought copper, sweat solder-joint type. Solder shall be 95/5 tin-antimony. Coordinate with mechanical

contractor prior to setting mechanical units to verify proper condensate fall. Air handler P-Trap depth shall be installed per mechanical plan P-trap depth instructions for each air handler. Refer to mechanical plans for P trap depths and coordinate with mechanical contractor on mechanical unit drain installations.

2.13 AUTOMATIC AIR VENTS

Provide automatic air vents at all high points of the hot water return system to release any trapped aid binds. Devices must be field located at each high point in the system. Provide Hoffman Model 79 or equal ¾" connection air vents with ball type isolator valve. Locate automatic air vent on full size tee riser branch off of elbow per details on plans. Missing air vents discovered at any time during warrantee period shall be installed by contractor at no additional cost to owner or others.

END OF SECTION

22 13 16
SANITARY WASTE AND VENT SYSTEM

PART 1 GENERAL

1.1 SCOPE

A. All waste and vent pipe above grade shall be service weight cast iron pipe. For below ground use solid core PVC schedule 40 pipe. For above grade, use no-hub pipe and fittings. Use approved pattern drainage type cast iron fittings on all waste and vent piping.

PART 2 DESIGN STANDARD

2.1 CI PIPING

No-hub cast iron, shall conform to CISPI #301-04a and ASTM A-888-04a. CI piping shall be marked with collective trademark of the Cast Iron Soil Pipe Institute. Offshore pipe is not acceptable. All pipe shall be manufactured in the USA.

2.2 CI FITTINGS

A. No-hub cast iron drainage pattern fittings, conforming to CISPI #301-04a. Fittings shall be marked with collective trademark of the Cast Iron Soil Pipe Institute. All fittings shall be manufactured in the USA.

B. Threaded cast iron fittings conforming to ANSI B16.4.

C. Threaded malleable iron fittings conforming to ANSI B16.3.

2.3 PIPE HANGERS AND SUPPORTS

A. Vertical and horizontal piping shall be supported per code and per manufacturer.

2.4 CI NEOPRENE GASKETS

A. Ty-Seal neoprene gasket conforming to ASTM C-5.

2.5 NO-HUB COUPLINGS FOR PIPE ABOVE GRADE

A. Stainless steel shield-clamp assembly with neoprene gasket conforming to CISPI 310. Screened stainless steel is not acceptable.

2.6 INSTALLATION

A. Pitch waste and drain lines at a uniform slope of 1/4" per foot minimum unless noted otherwise on the drawings.

B. Install wall cleanouts wherever possible for cleanout of stoppages.

C. Install cleanouts on waste lines at all change of directions, 100'-0" O.C. on straight runs and as required by local plumbing code. Make all cleanouts accessible by either being accessible within 6" of ceiling access panel, extended to floor or grade, or located in wall with removable plate. Provide 24” clearance all around cleanout.

END OF SECTION

22 40 01
Plumbing Fixtures

PART 1 GENERAL

1.1 SUMMARY

A. Fixtures specified on plans take precedence over this specification section. Refer to plans for specifications of plumbing fixtures.

B. Use polished chrome-plated, adjustable brass P-traps with wall escutcheons at all exposed locations. Provide brass fixture stops or valves ahead of all equipment or fixtures.

C. All flexible plumbing lines from stop valve to fixture shall be stainless steel wire braid reinforced and shall be manufactured in the United States only.

PART 2 DESIGN STANDARD

2.1 REFER TO PLANS.

END OF SECTION

SECTION 23 05 00

GENERAL PROVISIONS

GENERAL

PART 1 GENERAL

1.1 SCOPE

A. The intent of the guide specification is to provide direction to design professionals and contractors to specific levels of quality, expected practices and material selection. The design professional shall use this guide in conjunction with complete project technical specification prepared for each specific project by the design professional to meet the specific needs of each individual project.

B. Variations from products, methods, and materials anticipated as part of a specific project requirement should be brought to the attention of the Owner's project manager during the design process for review, comment and approval.

1.2 WORK AND MATERIALS

A. Uniformity: Unless otherwise specified, provide all equipment and products of same type or classification by the same manufacturer.

B. *Repair any fire protection removed or damaged by work in this Section in accordance with Section 07 81 00*

1.3 OPERATION AND MAINTENANCE MANUAL

A. Manuals shall be tabulated, indexed and bound in a three-ring binder. A preliminary submittal of the manual shall be made to the Architect 90 days after receiving approved submittals. Final submittal of the manual shall be made four weeks prior to substantial completion of the project.

1.4 SHOP DRAWINGS

A. Contractor shall provide all shop drawings and wiring diagrams complete with all connection details. Wiring diagrams shall not contain optional methods that do not apply. Wiring diagrams must be complete with all necessary information and must correctly indicate the conditions of this specific job.

B. Equipment layouts, drawn to a scale of 1/2" = 1'-0", including equipment piping and accessories, showing clearances for operating and servicing.

1.5 IDENTIFICATION

A. Equipment: Equipment shall be identified with engraved plates made of 3/32" thick laminated black Bakelite with white core. Engrave to produce 3/8" high white lettering on black background. Engraved plates shall be screwed on. The

identification shall correspond to the designation used on construction drawings and shall include, but not be limited to, the following: air handlers, condensing units, fans, pumps, temperature control equipment, etc.

B. Instruments and Controls: Identify all control devices; sensors, transducers, damper motors and automatic valves, flow switches and pressure switches, with engraved Bakelite nameplates with 3/8" high lettering, permanently affixed to each item with screws or short chain and S-hooks if drilling for screws could damage item, indicating service and, where applicable, normal setting.

C. Valves:

1. Carefully prepare chart or diagram for each piping system, indicating by number each valve in the system and each valve's location and function. Numbers used on valves shall correspond with chart.

2. Mount one of each chart in every mechanical equipment room applicable. Mount each chart in aluminum frame with clear glass front and secure to wall where directed.

3. Bind a copy of each chart in maintenance manuals.

4. Provide each valve with a brass or aluminum disc not less than 1-1/4" diameter and bearing 3/8" high, engraved numbers corresponding to those shown on chart. Fasten tag to valve with #14 brass wire.

D. Pipe:

1. Mark each individual pipe with Brady, Seton, Brimar, or Set Mark identification markers with flow arrows of snap-on type after pipe has been painted or insulated.

2. Install stencils at all major branch takeoffs, risers and at 10-foot intervals on straight runs and at each entrance or exit from pipe shafts. Markers shall be located for maximum visibility from expected personnel approach.

3. Identification material sizes shall be as follows:

a. 2" and Under: 1/2" high letters.

b. Over 2": 1" high letters.

Provide a typewritten schedule of all markers used, with identification framed under glass and posted in the Mechanical Equipment Room.

4. Identify pipe with following:

Service	Abbreviation
Chilled Water Supply	CHWS
Chilled Water Return	CHWR
Equipment Drains	D
Condensate Drains	CD

5. Pipe markers for piping not listed above shall conform to the latest ANSI and OSHA requirements.

1.6 GUARANTEE

A. Guarantee all material, equipment, installation and workmanship for all sections under Division 23 in writing to be free from defects of material and workmanship for one year from date of final acceptance as outlined in Division 01. Equipment warranties shall be a minimum of one year from date of substantial completion or as specified elsewhere.

PART 2 DESIGN STANDARD

2.1 EQUIPMENT DESIGN AND INSTALLATION

A. Design: Design all equipment in accordance with latest edition of ASME, AGA, UL and other applicable technical standards as follows:

1. Pressure Vessels: ASME Code constructed and stamped.

2. Electric Appliances: UL labeled.

3. Fans: AMCA rated and stamped.

4. Cooling Equipment: ARI certified.

5. Fire Dampers, Smoke Dampers, Combination Fire and Smoke Dampers: UL listed.

2.2 ACCESSIBILITY

A. Install valves, dampers, thermometers, gauges, traps, cleanouts, control devices or other specialties requiring reading, adjustment, inspection, repairs, removal or replacement in convenient and accessible locations throughout the finished building. Where any of these devices are shown on the contract drawings to be installed above any inaccessible ceiling or behind any inaccessible wall, the Mechanical Contractor shall furnish access doors or panels as required.

B. All access doors or panels in walls and ceilings required for access to control devices, traps, valves and similar devices are to be furnished and installed as part of the work under this section.

C. The Contractor, along with the Owner's representative, shall complete the

Mechanical Accessibility/Clearance Checklist at the end of this section for all mechanical equipment. The chart shall be submitted to the Architect/Engineer for approval prior to substantial completion. All conflicts shall be resolved to the Architect's/Owner's satisfaction prior to submission.

D. Do not place fan coils, air handlers, drip pans, etc. above electrical equipment or restrict electrical panel or other door openings.

PART 3 WARANTEE PERIOD TROUBLE SHOOTING SERVICES

Warrantee Period Trouble Shooting Services: The Mechanical Contractor shall provide the senior HVAC technician who completed the facility HVAC installation to attend up to six warrantee period trouble shooting meetings on site at the request of the engineer. Such meetings may be arranged to be attended jointly with the engineer, TAB contractor, and/or Controls Contractor to jointly assist in trouble shooting activities and to assist in the remedy of any building HVAC system operational difficulties. Such meetings may require additional adjustments or modification of systems, settings, sequences of operation, controls programming, TAB and similar refinements to obtain the best possible performance of the HVAC systems. Minor HVAC repair or warrantee services requested by the owner or others shall not be included in the count of six trouble shooting meetings. For any of the six meetings the HVAC contractor shall be prepared with tools and equipment necessary to make adjustments to HVAC systems and equipment as directed by the engineer.

END OF SECTION

MECHANICAL ACCESSIBILITY / CLEARANCE CHECKLIST									
			Acceptable Access					Observer	
Bldg.	Location	Unit #	Yes	No	Conflict	Date	Action	Owner	Contractor

SECTION 23 05 01

SUMMARY OF WORK FOR HEATING, VENTILATION & AIR CONDITIONING

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. The work specified in this section applies to all work required under the air conditioning, heating and ventilating sections of the specifications. Refer to the drawings and other sections of this division for work described herein.

PART 2 DESIGN STANDARD

2.1 EQUIPMENT

A. Approved Mechanical Equipment Manufacturers: Following is a list of manufacturers whose equipment is acceptable as to manufacture, subject to conformance with all drawings, specifications and addenda items. Careful checking must be made to verify that the equipment will meet all capacities, requirements and space allocations and that the weights are not excessive.

Access Door Latches: Vent Fabrics, Duro Dyne, Young, Millairelo, Ruskin, Cesco, Knudson.

Access Doors: Milcor, Ventfab, American Warming, Potter-Roemer, Cesco, Knudson, Ruskin.

Air Conditioning Units: Trane, Carrier.

Air Curtains: Mars, ILG, Greenheck, Ace.

Air/Dirt Separators: Bell and Gossett, Spirotherm or equivalent as approved by Operations and Maintenance.

Standard Air Handlers: Trane, Carrier

Air Vents: Spirotherm or equivalent as approved by FMD Operations and Maintenance.

Boilers: Cleaver-Brooks, Parker, Raypak.

Closed Cell Insulation: Halstead-Nomalco, Armstrong, Rubatex, Nomaco, Imcoa.

Condensate Pumps: Spirax/Sarco, Chicago, Weil, Bell & Gossett, Paco.

Convertors: Bell & Gossett, Taco.

Deaerator: Kewaunee, Cleaver-Brooks, Industrial Steam.

Duct and Pipe Insulation: Owens-Corning Fiberglas, CertainTeed, Manville, Knauf, Bonded Logic Ultratouch.

Ductless Split Air Conditioning System: Mitsubishi, Sanyo.

Duct Turns: United Sheet Metal, Duro Dyne, Elgen, Aero-Dyne.

Electric Heating Coils: Indecco, Chromolox, Redd-I, Warren Technologies.

Evaporative Cooler: United Metals, Champion, Phoenix.

Exhaust Fans: Carnes, Penn, Greenheck, Cook.

Exhaust Fans (Carbon Monoxide): Car-Mon.

Expansion Joints: Flex-Hose, Keyflex, Flexonics, Adsco, Tube-Turn, Aeroquip, Hyspan.

Expansion Tanks: Bell & Gossett, Armstrong, Wessells, Amtrol.

Fan Coil Units: Trane, Enviro-Tec, Carrier, International Environmental.

Filters: Farr, Continental, Burke, American Air Filters, Purolator.

Flexible Connectors: Flex-Hose, Keyflex, Flexonics, Metra Flex

Flexible Duct: Flexmaster, Thermaflex, Wiremold, Genflex, Manville, Owens-Corning, Atco Flex.

Flexible Duct Connections: Vent Fabrics, Duro Dyne, Elcen.

Grilles, Registers and Diffusers: Titus, Barber-Colman, Carnes, Krueger, Metalaire, Price.

Humidifiers: Armstrong, Dri-Steam, Nortec, Carnes.

Louvers: Air Stream, Airolite, Titus, Krueger, Carnes, Louvers & Dampers, Cesco, Dowco, Ruskin, Knudson, Vent Products, Metal-Form, Greenheck.

Manual Dampers: Greenheck, Honeywell, Johnson Service, Krueger, Carnes, Safe-Air, National Controlled Air, Ruskin, Knudson, Vent Products, Metal-Form.

Manual Quadrants: Farr, Vent Fabrics, Duro Dyne, Elcen, Safe-Air.

Markers and Signage: W. H. Brady, Seton.

Mechanical Grooved Fittings: Gustin Bacon, Victaulic, Gruvlok, Grinnell Mechanical Products.

Motors: Baldor, General Electric, U.S. Motor.

Motor Starters: Westinghouse, Square D, General Electric.

Outside Air Roof Intakes and Relief Air Hoods: Penn Ventilator, Greenheck, Breidert, Cesco, Knudson, Carnes, Jenn, Cook, Western Vents & Curbs, Metal-Form.

Pipe Hangers & Supports: Elcen, Grinnell, Amber-Booth, Kin-Line, Power Strut, Unistrut, F&S, Piping Technology & Products, B-Line Systems, Michigan Hanger Co., National Pipe Hanger Corp., PHD Manufacturing, PHS Industries, Pipe Shields Inc.

Plate and Frame Heat Exchangers: Alfa-Laval, Armstrong, Polaris, Bell and Gossett, Sondex.

Pressure Gauges: Marsh, Winters, Weksler, Palmer, Weiss, Miljoco.

Pressure Reducing and Relief Valves: Spirax/Sarco, Faris, Leslie.

Pumps: Bell & Gossett, Aurora, Peerless, Armstrong, Taco.

Round Duct: United McGill, Semco, Spiro-Fab, Metal Manufacturing.

Smoke and Fire Dampers: Air Balance Inc., Fire Seal, Ruskin, Advance Air Inc., Phillips, Safe-Air Inc., Prefco, Louvers & Dampers, Cesco, Greenheck, Pottorff.

Sound Attenuators: Industrial Acoustic Inc., Rink, VibroAcoustics.

Storage Tanks: Magna-Tanks, Patterson-Kelly, Ace Tank, Brown, Reco.

Strainers: Armstrong, Keckley, Sarco, Bush, Illinois, Padget, Strong, Watts.

Thermometers: Taylor, Weksler, Winters, Palmer, Johnson, Honeywell, Powers, Weiss, Miljoco.

Underground Chilled and Hot Water Piping: Ricwil Perma-Pipe, Thermacor, Rovanco, Urecon, Energy Task Force.

Unit Heaters: Reznor, Trane, McQuay, Wing, Modine, Sterling.

Valves (Automatic Flow Control): Griswold, Aquaduct, Nexus.

Valves (Ball, Check): Grinnell, Watts, Milwaukee, Nibco, Apollo, Hammond, FNW.

Valves (Butterfly): Grinnell, Nibco, Watts, Milwaukee, Hammond, FNW.

Valves (Plug): Homestead, De Zurik, Milwaukee.

Variable Frequency Drives: ABB.

Variable Volume Mixing Box: Titus, Trane, Krueger, Enviro-Tec.

Vibration Isolators: Mason, Vibration Mounting, Inc., Vibrex, Korfund, Amber-Booth, Dynamics, Vibration Eliminator Co., Caldyn.

Water Chillers: Trane, Carrier.

Water-to-Air Heat Pumps: Mammoth, Friedrich, Command Air, Enercon, Electro-Hydronic, Carrier, Trane, Water Furnace.

Water Treatment: ACT, Aqua Clear Engineering, Chemical Technologies, Nalco, ProChemTech, Betz, WES.

END OF SECTION

SECTION 23 05 10

BASIC PIPING METHODS

PART 1 GENERAL

1.1 SUMMARY

A. This section includes the following:

1. Piping materials and installation instructions common to most piping systems.

2. Transition fittings.

3. Dielectric protection.

4. Sleeves.

5. Escutcheons.

PART 2 DESIGN STANDARD

2.1 DIELECTRIC PROTECTION

A. Provide dielectric provisions at all points where copper or brass pipe or equipment is joined to ferrous pipe and equipment as follows:

1. For threaded x threaded connections, sizes 1/2" through 4", Victaulic CLEARFLOW waterway connector.

2. For threaded x grooved connections, sizes 1" through 4", Victaulic CLEARFLOW waterway connector.

3. For copper to steel flange connections, sizes 1-1/2" through 8", CTS copper flange adapter.

B. Dielectric insulating unions will not be accepted.

C. This requirement does not apply to brass valves in steel lines or joints between copper and cast iron drainage lines.

2.2 SLEEVES

A. Steel Pipe: ASTM A 53, Type E, Grade B, schedule 40, galvanized, plain ends.

B. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With setscrew and polished chrome-plated finish.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw and polished chrome-plated finish.

2.4 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

B. Install piping to permit valve servicing.

C. Uniformly grade all horizontal piping to provide for service drainage and air escapement. Where conditions do not permit constant pitch, establish intermediate low or high point, drop or rise to new level, and provide drain and air vent as required. Pitch pipes a minimum of 1 inch per 40 feet, in direction of flow, unless otherwise indicated or specified.

D. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions used for fire, smoke or sound control, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.

3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

a. Steel Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).

b. Stack Sleeve Fittings: For pipes penetrating floors with

membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint.

E. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using schedule 40 PVC sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

END OF SECTION

SECTION 23 05 13

ELECTRIC MOTORS

PART 1 GENERAL

1.1 SUMMARY

A. All motors shall be NEMA premium efficiency.

PART 2 DESIGN STANDARD

2.1 ELECTRICAL MOTORS

A. General:

1. Motors 3/4 HP and larger except as otherwise noted shall be designed for 3 phase, 60 hertz power supply.

2. Motors 1/2 HP and smaller, except as otherwise noted, shall be designed for 120 volt, single phase, 60 hertz power supply.

3. Motors connected to variable frequency drives shall be inverter duty rated, include Class F insulation or higher, and shall include Aegis or equal shaft grounding brushes.

4. Motors shall be approved by Underwriters' Laboratories (UL) for the service specified with a minimum service factor of 1.15.

5. All three phase motors shall be Premium Efficiency per NEMA MG1.

B. Motors not directly exposed to weather and located in nonhazardous spaces shall be in drip-proof enclosures.

C. Motors shall be totally enclosed, fan cooled where directly exposed to weather.

D. Single-phase motors shall have built-in overload protection of the single pole, automatic reset type. Use manual reset type where frequent start-stop may constitute a hazard.

E. Hermetic polyphase motors shall have built-in hermetic thermostatic protection devices to interrupt the control circuit and protect the motor from overheating. All motors shall be ball bearing type with a minimum of 1.15 safety factor.

2.2 MOTOR CONTROLLERS

A. Furnish motor controllers as specified herein. Design shall be in accordance with the latest applicable standards of NEMA and UL. The design shall have been tested in a recognized high power laboratory to prove adequate mechanical and

electrical capabilities. All components shall have been individually design tested and guaranteed by the manufacturer. Furnish controllers for all motors not fed from a motor control center. See electrical drawings.

1. For single phase motors without internal overload protection and three phase motors, provide starters as specified in this section.

2. For single-phase motors with internal overload protection, provide starters as above or definite purpose contactors per Paragraph 2.2F below.

B. Starters shall be Square D Class 8536 or equivalent. Starters shall be NEMA devices. IEC starters and NEMA rated IEC starters are not acceptable.

C. Non-reversing starter units shall consist of a full voltage magnetic starter providing external manual reset, thermal overload and low voltage protection. Each starter shall be equipped with indicating lights, auxiliary contacts, HOA's, control transformers, etc., as required for proper operation by the control system. (All starters shall be furnished with overloads in each phase leg, of size to be selected after final installed nameplate full load amperes of motors is determined.)

D. Starters to be installed indoors shall be provided in NEMA Type 1 enclosure.

E. Starters to be installed outside shall be provided in NEMA Type 4 enclosure.

F. Controllers for individual air handling equipment containing single phase motors with internal motor overload protection shall be allowed to be controlled by a NEMA Class Definite Purpose Contactor rated for the full load amperes of the motor. Contactors shall be Square D Company Type DPA, Class 8910, or equivalent by General Electric or Cutler-Hammer.

END OF SECTION

SECTION 23 05 14

VARIABLE FREQUENCY DRIVES (VFDS)

PART 1-GENERAL

1.01 DESCRIPTION

A. This specification is to cover a complete Variable Frequency motor Drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use on a standard NEMA Design B induction motor.
B. All HVAC OEM's (AHU, Pumps, Cooling towers, etc.) units shall be designed to interface / accommodate field or factory mounting of VFD's.
C. VFD's shall be of a single type/model supplied through one source from a single manufacturer's local factory certified Distributor that specializes in HVAC equipment / applications and has exclusive distribution responsibilities in the territory the VFD's are installed.
D. The local factory certified Distributor / DSS (Designated Service Station) shall have a minimum of ten (10) years experience with the specific manufacturer's product line and a staff of factory certified technicians and engineers specializing in HVAC applications. Distributor /DSS will provide all: Start-Up, Troubleshooting, Electrical, HVAC Mech. and BAS (Building Automation Systems) / DDC (Direct Digital Control) systems VFD integration & fine tuning, Applications Engineering, Technical Support, Training, On-site 24/7 Warranty & Harmonic Distortion testing, calculations, etc. to be performed in compliance with IEEE 519. If deemed necessary by consulting engineer, owner, etc. on-site harmonic distortion testing for total harmonic distortion (current and voltage) shall be provided and witnessed by consulting engineer, owner, etc. at no additional cost.
E. The drive manufacturer shall supply the drive and all necessary controls as herein specified. The manufacturer shall have been engaged in the production of this type of equipment for a minimum of twenty years.

1.02 RELATED DOCUMENTS

1.03 QUALITY ASSURANCE

A. Referenced Standards:
   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 Variable Speed Drives
   4. IEC 16800 Parts 1 and 2
   5. NEC Table 430-150 Full Load current for 3 phase AC motors
B. Qualifications:
   1. VFD's 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. The total unit consisting of VFD and integrated bypass shall be UL listed for 100,000 AIC (Available Interrupting Current) without input fuses.

2. CE Mark – The VFD shall conform to the European Union ElectroMagnetic Compatibility directive, a requirement for CE marking. The VFD shall meet product standard EN 61800-3 for the First Environment restricted level.
3. Acceptable Manufacturers/Model and Factory certified representative/distributor:
   ABB ACH 550 Series by Mech-Line Services, Baldor or Allen Bradley
4. Owner and Engineer approval is required for alternate product, service and local factory certified distributor, etc. 3 weeks prior to the bid due date, to allow sufficient time for owner and engineer review of submitted alternates.
5. ALL exceptions to this specification shall be addressed in written form for approval and does not relieve supplier of specification requirements. The documentation for the alternate product/service submitted shall be in the same chronological order and format as this specification and state either compliance or exception to each item by specification section number. For each exception there shall be a written response detailing the feature, function and benefit of the alternate item to the product / service specified and be listed by specification section number. Original manufacturers factory documented information must be provided to support each compliance, exception and alternate and each specification section number must be denoted on the original factory documented information. Three (3) duplicate copies of this documentation shall be submitted for review.
   a) VFD's that are manufactured and/or assembled and/or modified, etc. by a third party and/or "brand labeled" shall not be acceptable.

1.04 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
   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 line 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% equivalent impedance input reactors, no exception.

PART 2 – PRODUCTS

2.01 VARIABLE FREQUENCY DRIVES

A. The VFD package as specified herein shall be pulsed width modulated (PWM) output wave form. Each VFD shall be completely assembled and tested by the manufacturer. The VFD shall employ a full wave rectifier to prevent input line notching, dc bus choke, dc bus filter capacitors, and insulated gate bipolar transistors (IGBT's) as the output switching device all enclosed in a UL Listed Type 1 or 12 indoor or NEMA 3R outdoor enclosure as specified here in and be completely assembled and tested by the manufacturer in a certified UL 508 and/or 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. 1 thru 50 HP, 480 & 230 volt, NEMA 1 indoor and all NEMA 3R outdoor enclosures shall be capable of continuous operation at -15 to 50 deg. C (5 to 120 deg. F) ambient temperature as per VFD manufacturers documented/submittal data or VFD must be oversized. NEMA 3R outdoor enclosure with VFD must be mounted in a shaded area that is not in direct sun light.
2. 60 thru 550 HP, 480 & 230 volt, NEMA 1 indoor enclosures shall be capable of continuous operation at -15 to 40 deg. C (5 to 104 deg. F) ambient temperature; From 40 to 50 deg. C (104 to 120 deg. F), current de-rate as per VFD manufacturers documented/submittal data or VFD must be oversized.
3. Environmental operating conditions: -15 to 40°C continuous. VFD's that can operate at 40° C intermittently (during a 24 hour period) are not acceptable and must be oversized. Altitude 0 to 3300 feet above sea level, less than 95% humidity, non-condensing.
4. Enclosure shall be rated UL type 1 and shall be UL listed as a plenum rated VFD. VFD's without these ratings are not acceptable.

B. All VFD's shall have the following standard features:

1. All VFD's 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 VFD's.
2. The keypad shall include Hand-Off-Auto selections and manual speed control. The drive shall incorporate "bumpless transfer" of speed reference when switching between "Hand" and "Auto" 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. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter sets and output 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, operating temperature will be monitored and used to cycle the 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 setpoint without safety 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 430-150 for 4-pole motors.
9. The VFD shall have an integral 5% impedance input line reactors 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 5% impedance input AC line reactors.
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 430-2.
11. The VFD shall include a coordinated AC transient 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 be capable of sensing a loss of load (broken belt / broken coupling) and signal the loss of load condition. The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. Relay outputs shall include programmable time delays that will allow for drive acceleration from zero speed without signaling a false underload condition.
13. 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, relay output and/or over the serial communication bus.
14. 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.

D. All VFD's 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.
2. Two (2) PID Setpoint 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 setpoint shall be adjustable from the VFD keypad, analog inputs, or over the communications bus. There shall be two parameter sets for the first PID that allow the sets to be switched via a digital input, serial communications or from the keypad for night setback, summer/winter setpoints, etc. There shall be an independent, second PID loop that can utilize the second analog input and modulate one of the analog outputs to maintain setpoint of an independent process (ie. valves, dampers, etc.). All setpoints, process variables, etc. to be accessible from the serial communication network. The setpoints shall be set in Engineering units and not require a percentage of the transducer input.
3. Two (2) programmable analog inputs shall accept current or voltage signals.
4. 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, and other data.

5. Six (6) programmable digital inputs for maximum flexibility in interfacing with external devices, typically programmed as follows:
   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 or valve to open (VFD motor does not operate). When the damper or valve 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 or valve shall be commanded to close. The keypad shall display “start enable 1 (or 2) missing”. The safety status shall also be transmitted over the serial communications bus. All digital inputs shall be programmable to initiate upon an application or removal of 24VDC.
6. Three (3) programmable digital Form-C relay outputs. The relays shall include programmable on and off delay times and adjustable hysteresis. Default settings shall be for run, not faulted (fail safe), and run permissive. The relays shall be rated for maximum switching current 8 amps at 24 VDC or 250 VAC and 0.4 A at 120 VDC; Maximum voltage 300 VDC and 250 VAC; Max. continuous current rating 2 amps RMS. Outputs shall be true form C type contacts; open collector outputs are not acceptable.
7. Seven (7) programmable preset speeds.
8. Two independently adjustable accel and decel ramps with 1 – 1800 seconds adjustable time ramps.
9. The VFD shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and audible motor noise.
10. The VFD shall include a carrier frequency control circuit that reduces the carrier frequency based on actual VFD temperature that allows the highest carrier frequency without derating the VFD or operating at high carrier frequency only at low speeds.
11. The VFD shall include password protection against parameter changes.

E. 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). The keypad shall utilize the following assistants:
   1. Start-up assistants; 2. Parameter assistants; 3. Maintenance assistant; 4.Troubleshooting assistant

F. 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):
   Output Frequency; Motor Speed (RPM, %, or Engineering units); Motor Current; Calculated Motor Torque; Calculated Motor Power (kW); DC Bus Voltage; Output Voltage

G. The VFD shall include a fireman’s override input. Upon receipt of a contact closure from the fireman’s control station, the VFD shall operate at an adjustable preset speed. The mode shall override all other inputs (analog/digital, serial communication, and all keypad commands) and force the motor to run at the adjustable, preset speed. “Override Mode” shall be displayed on the keypad. Upon removal of the override signal, the VFD shall resume normal operation.

H. Serial Communications

1. The VFD shall have an RS-485 port as standard. The standard protocols shall be BACnet, Modbus RTU, Johnson Controls N2 bus, and Siemens Building Technologies FLN. Protocols for Lon Works, 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. All protocols shall be "certified" by the governing authority. Use of non-certified protocols is not allowed.
2. The BACnet connection shall be an RS485, MSTP interface operating at 9.6, 19.2, 38.4, or 76.8 Kbps. The connection shall be tested by the BACnet Testing Labs (BTL) and be BTL Listed. The BACnet interface shall conform to the BACnet standard device type of an Applications Specific Controller (B-ASC). The interface shall support all BIBBs defined by the BACnet standard profile for a B-ASC.
   If additional hardware is required to obtain the BACnet interface, the VFD manufacturer shall supply one BACnet gateway per drive. Multiple VFD's sharing one gateway shall not be acceptable.
3. 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. The following additional status indications and settings shall be transmitted over the serial communications bus – keypad "Hand" or "Auto" selected, bypass selected, the ability to change the PID setpoint, and the ability to force the unit to bypass (if bypass is specified). The DDC system shall also be able to monitor if the motor is running in the VFD mode or bypass mode (if bypass is specified) over serial communications. A minimum of 15 field parameters shall be capable of being monitored.
3. The VFD shall allow the DDC to control the drive's digital and analog outputs via the serial interface. This control shall be independent of any VFD function. For example, the analog outputs may be used for modulating chilled water valves or cooling tower bypass valves. The drive's digital (relay) outputs may be used to actuate a damper, open a valve or control any other device that requires a maintained contact for operation. In addition, all of the drive's digital and analog inputs shall be capable of being monitored by the DDC system.
4. 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 control, etc. Both the VFD control PID loop and the independent PID loop shall continue functioning even if the serial communications connection is lost. 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.

I. EMI / RFI filters. All VFD's shall include EMI/RFI filters. The onboard filters shall allow the VFD assembles to be CE Marked and the VFD shall meet product standard EN 61800-3 for the First Environment restricted level, <u>no exceptions.</u>

J. All VFD's through 60HP shall be protected from input and output power mis-wiring. The VFD shall sense this condition and display an alarm on the keypad.

K. OPTIONAL FEATURES –Feature are to be drive manufacturer provided and be UL Listed as a UL 508 labeled complete assembly.

L. BYPASS CONTROLLER A factory wired and tested VFD & bypass "system" hardware consisting of a door interlocked, padlockable circuit breaker, output contactor, bypass contactor, and fast acting VFD isolation fuses, manual or automatic modes & overloads. Three contactor bypass schemes are not acceptable, as a VFD input contactor is not a NEC recognized, lockable, physical disconnect and is an unacceptable means of safely disconnecting power to any VFD.
   1. The bypass enclosure door and VFD enclosure must be mechanically interlocked such that the disconnecting device must be in the "Off" position before either enclosure may be accessed.
   2. The VFD bypass system shall have a UL listed SCCR (short circuit current rating)/AIC (Amperage Interupting Capacity) of 100,000 amps and be documented on the UL data label.
   3. The VFD bypass system shall be seismic certified and labeled to the IBC: Seismic importance factor of 1.5 rating is based on actual shake test as defined by ICC AC-156.
   4. Drive Isolation Fuses - Fast acting fuses, exclusive to the VFD to allow the VFD to disconnect from the line to maintains bypass operation capability in the event of a VFD failure.
   5. The VFD bypass system tolerated voltage window shall operate from a line of ±30% nominal voltage range
   6. The bypass system shall protect contactor coil from failure during brown out / low line conditions and allow for input single phase operation when in the VFD mode.
   7. System will provide motor protection from single phase power conditions and detect a single phase input power condition while running in bypass, disengage the motor and provide indication of single phase input power.
   8. The system shall NOT depend on the VFD to be installed for bypass operation. Bypass stand alone operation shall be completely functional in both Hand and Automatic modes even if the VFD has been removed for repair/replacement. Bypass system serial communications shall remain functional with the VFD removed to provide HVAC system temperature control.
   9. Serial communications – the bypass system shall be monitored and/or controlled via serial communications to provide HVAC system temperature control. On-board communications protocols shall include ModBus, Johnson Controls N2, Siemens Building Technologies FLN (P1), BACnet MS/TP and Lon Works available.
   10. The system shall include run permissive feature with field programmable time delay from 0 – 120 seconds, for bypass start and indication on keypad time delay is in process. A Form C relay output shall provide a contact closure to signal the VAV boxes, valves, etc. to open. This will allow BAS/DDC ATC (automatic temperature control) valves, VAV boxes, dampers, etc. to be driven open before the motor operates at full speed in the bypass mode.
   11. User selectable text shall be displayed on the keypad when an external safety opens. Text display indications include "FireStat", "FreezStat", "Over pressure", "Low suction", etc. The user shall define over the serial communications connections, up to four (4) customer safety contacts being opened.
   12. Smoke Control Override Mode (Override 1) – The bypass unit shall include a dedicated digital input that will transfer motor from VFD mode to bypass mode upon receipt of a dry contact closure from the Lie Safety Fire / Smoke Control System. In this Smoke control mode the

system will ignore low priority safeties and acknowledge high priority safeties as required by UL 864/UUKL. All keypad control, serial communications control, and normal customer start / stop control inputs will be disregarded.

13. Fireman's Override Mode (Override 2) – the bypass unit shall include a second, programmable override input allowing the user to configure the unit to acknowledge selectable digital inputs. This will allow the user to program the bypass system to react in whatever manner the local Authority Having Jurisdiction (AHJ) requires. The Override 2 action may be programmed for "Run-to-Destruction". The user may also force the unit into Override 2 via the serial communications link.
14. Class 10, 20, or 30 (selectable) electronic motor overload protection shall be included.

PART 3 – EXECUTION

3.00INSTALLATION

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 installation manual.
B. Power wiring shall be completed by the electrical contractor, BAS / DDC contractor, etc. The contractor shall complete all wiring in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

3.01START-UP

A. Certified factory start-up shall be provided for each drive by the same local factory certified Distributor who is also responsible for supplying the VFD's. 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.

3.02PRODUCT 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 365/24 technical support shall be local for on-site support. 4 hour training class shall include programming and operation of the VFD& bypass configuration.

3.03WARRANTY

A. Warranty shall be 36 months on site PARTS & LABOR from date of shipment with certified start-up. The warranty shall include all parts, labor, travel time and expenses to on site location and factory certified technicians shall be available 365/24 via a local phone number and/or on-site as required.

End of Section

SECTION 23 05 23

VALVES (Other Than Control Valves)

PART 1 GENERAL

1.1 QUALITY ASSURANCE

A. Valve Types: All valves shall be of the same manufacturer unless otherwise specified.

B. All grooved joint valves shall be the products of the same manufacturer as the adjoining couplings.

PART 2 DESIGN STANDARD

2.1 GENERAL

A. All valves shall be supplied with identification tags supplied by the manufacturer. All valves shall be same size as connected piping unless noted otherwise.

B. Provide valves recommended by manufacturer for use in service indicated. Provide valves of types and pressure ratings indicated. Where more than one type is indicated, selection is Installer's option. Valves shall be of the same make for all these services.

2.2 CONDENSER AND CHILLED WATER

A. Valves 2" and Smaller:

1. Ball Valves:

a. Valves shall have two-piece cast bronze bodies, TFE seats, full port, separate packnut with adjustable stem packing, anti-blowout stems.

1) 316 stainless steel.

2) 316 stainless steel ball.

3) Valve ends shall have:

a) Full depth ANSI threads or extended solder connections and be manufactured to comply with MSS-SP110.

b. Acceptable Valves, Full Port: NIBCO T-585-70-66, Hammond 8503/8901/8301 (threaded); NIBCO S-585-70-66 or Hammond 8311/8911/8513 (solder).

c. NOTE: Where piping is insulated, ball valves shall be equipped with 2" extended handles of non-thermal conductive material. Also, provide a protective sleeve that allows operation of the valve without breaking the vapor seal or disturbing the insulation. Memory stops, which are fully adjustable after insulation is applied.

d. Acceptable Valves Full Port: NIBCO T-585-70-66-NS, Hammond 8503/8901/8301 (threaded); NIBCO S-585-70-66-NS or Hammond 8311/8911/8513 (solder).

B. Valves 2-1/2" and Larger:

1. Butterfly Valves:

a. Valves shall be lug body style manufactured in accordance with MSS-SP67 rated at least 200 PSI non-shock cold water working pressure. Body to have 2" extended neck for insulating and to be cast iron or ductile iron. Valve to have aluminum bronze alloy disc with EPDM rubber seat and seals, or EPDM rubber encapsulated disc with polymer-coated body. Stem shall be 400 series stainless steel and shall not have exposed stem to disc fasteners. Sizes 2-1/2" - 6" shall be lever operated with 10 position throttling plate; size 8" and larger shall have weatherproof gear operators. Lug-style shall be capable for use as isolation valves and recommended by manufacturer for dead-end service at full pressure without the need for downstream flanges.

b. Acceptable Valves:

1) Lug Body, Aluminum Bronze Disc: NIBCO LD2000-3 or Hammond 6211 (lever operator); NIBCO LD2000-5 or Hammond 5211 (gear).

2) Lug Body, Rubber-Coated Disc: NIBCO LC2860-3 (lever); LC2860-5 (gear).

C. Check Valves:

1. Check valves 2-1/2" and smaller shall be Y-pattern swing type manufactured in accordance with MSS-SP80, Class 125, bronze ASTM B-62 body with TFE seat disc. Where higher operating pressures approach 150 PSI, Class 150 valves of like construction shall be used. Valve ends may be threaded or solder-type.

a. Acceptable Valves:

1) Class 125: NIBCO T-413-Y or Hammond IB904 (threaded); NIBCO S-413-Y or Hammond IB912 (solder).

2) Class 150: NIBCO T-433-Y or Hammond IB946 (threaded), NIBCO S-433-Y or Hammond IB945 (solder).

2. Check valves 2-1/2" and larger shall either be swing-type manufactured in accordance with MSS-SP71, Class 125, flanged ASTM A126 Class B cast iron body with bronze trim, non-asbestos gasket, or wafer style with stainless steel spring, bronze disc plates, rubber seat, body of cast iron ASTM A126 Class B or A48 for use with Class 125/150 flanges. Spring-actuated valve to be used on pump discharge.

a. Acceptable Valves:

1) Swing-Type: NIBCO F-918-B or Hammond IR1124.

2) Spring-Actuated Wafer-Type: NIBCO W920W, KW900W, W910W, or Hammond IR9253.

D. Automatic Flow Control Valves: See control specifications 23 09 00.

END OF SECTION

SECTION 23 05 29

HANGERS AND SUPPORTS

PART 1 GENERAL

1.1 SUMMARY

A. This section includes hangers and supports for piping systems and equipment.

B. Size all hangers on insulated piping to fit outside covering.

C. All hangers, rods, and fastener materials shall be galvanized or stainless steel.

D. Hanger Rod Sizes:

Pipe Size	Rod Diameter (Inches)
2" and smaller	3/8
2-1/2" and 3"	1/2
4" and 5"	5/8
6"	3/4
8" through 14"	7/8

E. Hanger Rod Spacing (Horizontal Piping):

Pipe	Max. Hanger Spacing (Ft. O.C.)
Steel pipe 3/4" and smaller	6
Steel pipe 1"	8
Steel pipe 1-1/4" through 12"	10
Steel pipe 14" and larger	12
Copper tubing 1-1/4" and smaller	6
Copper tubing 1-1/2" and larger	8
Special piping materials	As recommended by manufacturer

PART 2 DESIGN STANDARD

2.1 HANGER AND SUPPORT INSTALLATION

A. Provide hangers at all offsets, tees, within 12" of all horizontal elbows, and elsewhere as herein described.

B. Sleeve and seal air and watertight all piping passing through exterior walls, through plenum or fire walls above ceilings. All sealers shall be waterproof and fireproof.

C. Insulated Piping: Comply with the following:

1. Thermal-hanger shield inserts shall be used. Include steel weight-distribution plate for pipe NPS 4 (DN100) and larger if pipe is installed on rollers.

2. Shield Dimensions for Pipe: Not less than the following:

   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.

   b. NPS 4: 12 inches long and 0.06 inch thick.

SECTION 23 05 48

VIBRATION CONTROL

PART 1 GENERAL

1.1 GENERAL REQUIREMENTS FOR THE MANUFACTURER

A. Equipment: Provide vibration isolators, base frames, and inertia bases of sufficient size and distribution to assure that deflection, stability and restraint requirements are met. For typical units, no fewer than four isolators shall be provided. Isolators shall be provided to deflect uniformly under operating gravity and equipment thrust loadings to within 10% of specified deflection values.

1.2 GENERAL REQUIREMENTS FOR THE CONTRACTORS

A. Short-Circuiting: Rigorously avoid short-circuiting to the building any vibration-isolated piece of equipment, pipe, duct or other component. Short-circuits with or via rigid conduits, drain lines, rigid braces, rigid sleeves, framing, etc., shall all be avoided.

PART 2 DESIGN STANDARD

2.1 VIBRATION CONTROL MATERIALS AND SUPPORT UNITS

A. Unless otherwise noted on the equipment schedule, all mechanical equipment shall be mounted on vibration isolators to prevent the transmission of vibration and mechanically transmitted sound to the building structure. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonable uniform deflection. Isolator types referenced herein are manufactured by Mason Industries, unless noted otherwise.

B. Mountings:

1. Style A: Double deflection neoprene mountings shall have a minimum static deflection of 0.35". All metal surfaces shall be neoprene covered to avoid corrosion and have friction pads both top and bottom so they need not be bolted to the floor. Bolt holes shall be provided for these areas where bolting is required. On equipment such as small vent sets and close-coupled pumps, steel rails shall be used above the mountings to compensate for the overhang. Mountings shall be type ND or rails type DNR.

2. Style B: Spring type isolators shall be freestanding and laterally stable without any housing and complete with 1/4" molded, non-skid, neoprene acoustical friction pads between the base plate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum

additional travel to solid equal to 50% of the rated deflection. Submittals shall include spring diameters, deflections, compressed spring height, and solid spring height. Mountings shall be type SLFH.

3. Style D: Equipment with operating weight different from the installed weight, such as chillers, boilers, etc., and equipment exposed to the wind, such as cooling towers, shall be mounted on spring mountings as described in Style B, but a housing shall be used that includes vertical limit stops to prevent spring extension when weight is removed. The housing shall serve as blocking during erection and cooling tower mounts shall be located between the supporting steel and roof or the grillage and dunnage as shown on the drawings. The installed and operating heights shall be the same. A minimum clearance of 1/2" shall be maintained around restraining bolts and between the housing and the spring so as not to interfere with the spring action. Limit stops shall be out of contact during normal operations. Mountings used out of doors shall be hot-dipped galvanized. Mountings shall be SLR.

4. Style D2 - Neoprene Pad(s) and Bearing Plate(s): Neoprene pad shall be ribbed or waffled, 5/16" to 1/2" thick, 40 durometer with a minimum 1/16" steel bearing plate on top. Size pad and bearing plate to receive 60 PSI load. Provide single or multiple pads and plates as required with 1/16" thick steel shim between layers. Mountings shall be Type “W” or “WM”.

5. Style D3 - Neoprene Bushing for Bolt Holes in Pads: Bushings shall be minimum 3/16" thick in all places and maximum 40 durometer. Provide steel washer to distribute bolt head loads to bushing. Provide bushings by Mason.

C. Hangers:

1. Style F: Vibration hangers shall contain a steel spring and 0.3" deflection neoprene element in series. The neoprene element shall be molded with a rod isolation bushing that passes through the hanger box. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30-degree arc before contacting the hole and short-circuiting the spring. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include a scale drawing of the hanger showing the 30-degree capability. Hangers shall be type 30N.

2. Style F1 - Neoprene Hanger: Vibration isolation hanger shall consist of double deflection neoprene-in-shear element contained in a steel housing. It shall be formed with a projecting neck bushing for the hole in the hanger housing to prevent metal-to-metal contact between the hanger rod and housing. The diameter of the hole shall be sufficient to permit the hanger rod to swing through a 30-degree arc before contacting the hanger housing. Neoprene shall be no harder than 50 durometer. Mounting shall be Type HD.

3. Style G: Vibration hangers shall be as described for Style F, but they shall be pre-compressed to the rated deflection so as to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Hangers shall be type PC30N.

4. Style H: Vibration hangers shall contain a steel spring located in a neoprene cup manufactured with a grommet to prevent short-circuiting of the hanger rods. The cup shall contain a steel washer designed to properly distribute the load on the neoprene and prevent its extrusion. Spring diameter and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30-degree arc before contacting the hole and short-circuiting the spring. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Hangers shall be provided with an eye bolt on the spring end and provision to attach the housing to the flat iron duct straps. Submittals shall include a scale drawing of the hanger showing the 30-degree capability. Hangers shall be type W30.

D. Bases:

1. Style J: Vibration isolator manufacturer shall furnish integral structural steel bases. Bases shall be rectangular in shape for all equipment other than centrifugal refrigeration machines, which may be "T" or "L" shaped. All perimeter members shall be beams with a minimum depth equal to one-tenth of the longest dimension of the base. Beam depth need not exceed 14" provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer. Height-saving brackets shall be employed in all mounting locations to provide a base clearance of 1". Bases shall be type WF.

2. Style K: Vibration isolator manufacturer shall provide steel members welded to height-saving brackets to cradle machines having legs or bases that do not require a complete supplementary base. Members shall be sufficiently rigid to prevent strains in the equipment. Inverted saddles shall be type ICS.

3. Style L: Vibration isolator manufacturer shall furnish rectangular structural beam or channel concrete forms for floating foundations. Bases for split case pumps shall be large enough to provide support for suction and discharge base ells. The base depth need not exceed 12" unless specifically recommended by the base manufacturer for mass or rigidity. In general, bases shall be a minimum of one-twelfth of the longest dimension of the base, but not less than 6". Forms shall include minimum concrete reinforcement consisting of 1/2" bars of angles welded in place on 6" centers running both ways in a layer 1-1/2" above the bottom, or additional steel as is required by the structural conditions. Forms shall be furnished with drilled steel members with sleeves welded below the holes to receive equipment anchor bolts where the anchor bolts

fall in concrete locations. Height-saving brackets shall be employed in all mounting locations to maintain a 1" clearance below the base. Bases shall be type K.

4. Style M: Curb mounted rooftop equipment shall be mounted on vibration isolation bases that fit over the roof curb and under the isolated equipment. The extruded aluminum top member shall overlap the bottom to provide water runoff independent of the seal. Aluminum members shall house electro-galvanized or powder coated springs selected for 0.75" (20mm) minimum deflection. Travel to solid shall be 1.5" (40mm) minimum. Spring diameters shall be no less than 0.8 of the spring height at rated load. Wind resistance shall be provided by means of resilient snubbers in the corners with a minimum clearance of 1/4" (6mm) so as not to interfere with the spring action except in high winds, Manufacturer's self adhereing closed cell sponge gasketing must be used both above and below the base and a flexible EPDM duct like connection shall seal the outside perimeter. Foam or other sliding or shear seals are unacceptable in lieu of the EPDM ductlike closure. Submittals shall include spring deflections, spring diameters, compressed spring height and solid spring height as well as seal and wind resistance details. Curb mounted bases shall be Type CMAB as manufactured by Mason Industries, Inc.

5. Style N: Curb mounted rooftop equipment shall be mounted on spring isolation curbs. The lower member shall consist of a sheet metal Z section containing adjustable and removable steel springs that support the upper floating section. The upper frame must provide continuous support for the equipment and must be captive so as to resiliently resist wind forces. All directional neoprene snubber bushings shall be a minimum of 1/4" (6mm) thick. Steel springs shall be laterally stable and rest on 1/4" (6mm) thick neoprene acoustical pads. Hardware must be plated and the springs provided with a rust resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing nailed over the lower curbs waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2" (50mm) of insulation. Curb shall be type RSC as manufactured by Mason Industries, Inc.

E. Flexible Connections:

1. Flexible Hoses:

a. Style O - Flexible Pipe Connectors: Flexible pipe connectors shall be fabricated of multiple plies of kevlar cord, fabric, and neoprene, vulcanized so as to become inseparable and homogeneous. Straight connectors shall be formed into a double sphere shape. Elbow connectors shall have a single sphere shape at the curve of the unit. Flexible connectors shall be able to accept compressive, elongating, transverse, and angular movements. Flexible

connectors shall be selected and specially outfitted if necessary to suit the system temperature, pressure, and fluid type. Connectors for pipe sizes 2 inches and smaller shall have threaded female union couplings on each end. Larger sizes shall be fitted with metallic flange couplings. Control cables shall be provided if required. Unit shall be “MFDEJ” or “SFDEJ”.

2. Piping connections to pumps shall be furnished with braided pump connectors. Braided pump connectors shall feature 321 stainless steel inner corrugated hose and 304 stainless steel braid reinforcing. The live length of corrugated inner hose shall be no less than 175% of the outside diameter of the pipe. Connection of the stainless corrugated hose to the flange or end fitting shall be welded. Flanges or end connections shall also be stainless steel. The entire assembly shall have a 4:1 safety design pressure factor. Installation shall be per manufacturer’s installation instructions and shall not pre-load, bend, twist or strain the flexible connection. Flex-Hose Pumpsaver Braided Pump Connectors or equal shall be supplied.

3. Flexible Duct Connections - Style O2: Fabricate flexible sleeves, for connecting ducts to fans, of neoprene-impregnated fabric or loaded vinyl, as scheduled. Sleeve material shall be impervious to air. Loaded vinyl shall weigh minimum 1 pound per square foot and shall be “Duro-Dyne” by Durolon or equal.

F. Acoustical Floor, Ceiling and Wall Seal - Style Q: Where piping passes through equipment walls, floors or ceilings, the vibration isolator manufacturer shall provide a split seal consisting of two bolted pipe halves with 3/4" or thicker neoprene sponge bonded to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Concrete may be packed around the seal to make it integral with the floor, wall or ceiling if the seal is not already in place around the pipe prior to the construction of the building member. Seals shall project a minimum of 1" past either face of the wall. Where temperatures exceed 240EF, 10-pound density fiberglass may be used in lieu of the sponge. Seals shall be type SWS.

G. Acoustical Floor, Ceiling and Wall Seal:

1. Style Q2 - Pipe Sleeve at Support or Construction Penetration: Sleeve shall consist of a formed and stiffened galvanized sleeve lined on the inside with moisture- and vermin-resistant felt bonded to the metal sleeve, and sleeve inside diameter shall equal pipe outside diameter plus 1". Sleeve lengths shall extend a minimum of 3" beyond penetration, or more if recommended by manufacturer. Provide “PR-Isolator” by Porter-Roemer, “Trisolator” by Stoneman Engineering, or approved equal.

H. Pipe Anchors - Style R: Vibration isolator manufacturer shall provide an all-directional acoustical pipe anchor consisting of a telescopic arrangement of two sizes of steel tubing separated by a minimum 1/2" thickness of heavy-duty neoprene and duck or neoprene isolation material. Vertical restraints shall be

provided by similar material arranged to prevent vertical travel in either direction. Allowable loads on the isolation material shall not exceed 500 PSI, and the design shall be balanced for equal resistance in any direction. All-directional anchors shall be type ADA.

I. Horizontal Thrust Restraints - Style I: Air handling equipment shall be protected against excessive displacement that might result from high air thrusts in relation to the equipment weight. The horizontal thrust restraint shall consist of a spring element in series with a neoprene pad as described in Style B with the same deflection as specified for the mounting of hangers. The spring element shall be contained within a steel frame and designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of 1/4" movement at start and stop. The assembly shall be furnished with one rod and angle brackets for attachment to both the equipment and ductwork or the equipment and the structure. Horizontal restraints shall be attached at the centerline of thrust and symmetrically on either side of the unit. Horizontal thrust restraints shall be type WB. Air handling equipment specified on plans as internally vibration isolated or designed to rest directly on concrete bases per the manufacturer's installation instructions shall not be furnished with additional spring isolators. Refer to plans for specific support instructions on each air handler on the project.

J. Horizontal Pipe Isolation:

1. Equipment Room Seals: All piping passing through equipment room walls, floors or ceilings and all piping passing through airtight walls, floors or ceilings shall be protected against sound leakage by means of an acoustical wall seal as described in Style M.

K. Custom Resilient and Airtight Sleeve Materials: Sleeve shall be custom-fabricated. It shall be formed from pipe or sheet metal that is one inch larger in cross-sectional dimension than penetrating element and is four inches longer than the thickness of the construction penetrated (2" extension on both sides). The annular space between the sleeve and the penetrating element shall be packed tightly with long fiberglass fibers of 2- to 3-PCF density to within 1/2" of the ends of the sleeve. The remaining 1/2" space at each end shall be filled completely with acoustical sealant to form an airtight sleeve. Fiberglass packing by Certainteed, Manville or Owens-Corning. Acoustical sealant by DAP, Tremco, or U.S. Gypsum.

2.2 VIBRATION ISOLATION SCHEDULE

	ISOLATION AND DEFLECTION CRITERIA FOR 4" (100mm) THROUGH 6" (150mm) THICK SOLID CONCRETE FLOORS (Notes 6 & 7)									
	Ground Supported Slab or Basement		20' (6m) Floor Span Possible Floor Defl.-0.67" (17mm)		30' (9m) Floor Span Possible Floor Defl.-1.0" (25mm)		40' (12m) Floor Span Possible Floor Defl.-1.33" (34mm)		50' (15m) Floor Span Possible Floor Defl.-1.67" (42mm)	
	Isolation Spec.	Isol. Defl. in.(mm)	Isolation Spec.	Isol. Defl. in.(mm)	Isolation Spec.	Isol. Defl. in.(mm)	Isolation Spec.	Isol. Defl. in.(mm)	Isolation Spec.	Isol. Defl. in.(mm)
REFRIG. MACHINES										
Absorption Machines	A-O	0.35 (9)	D-O	0.75 (20)	D-O	0.75 (20)	D-O	1.5 (40)	D-O	1.5 (40)
Centrifugal Chillers or Heat Pumps										
Cooler Condenser Mounted Hermetic Compressors	A-O	0.35 (9)	D-O	0.75 (20)	D-O	1.5 (40) Max 3Hz	D-O	1.5 (40) Max 3Hz	D-K-O	2.5 (65) Max 3Hz
Cooler Condenser Alongside Hermetic Compressors	A-O	0.35 (9)	D-O	0.75 (20)	D-O	1.5 (40) Max 3Hz	D-O	1.5 (40) Max 3Hz	D-O	2.5 (65) Max 3Hz
Open Drive Type Compressors (Note 3)	A-J-O	0.35 (9)	D-J-O	0.75 (20)	D-J-O	1.5 (40) Max 3Hz	D-J-O	1.5 (40) Max 3Hz	D-J-O	2.5 (65) Max 3Hz
Refrig. Reciprocating Compressors										
500 rpm to 750 rpm	B	0.75 (20)	B	1.5 (40)	B	1.5 (40)	B-K	2.5 (65)	B-K	3.5 (90)
751 rpm and Over	B	0.75 (20)	B	0.75 (20)	B	1.5 (40) Max 3Hz	B-K	2.5 (65) Max 3Hz	B-K	3.5 (90) Max 3Hz
Reciprocating Chillers or Heat Pumps										
500 rpm to 750 rpm	D-O	0.75 (20)	D-O	1.5 (40)	D-O	1.5 (40)	D-K-O	2.5 (65)	D-K-O	3.5 (90)
751 rpm and Over	D-O	0.75 (20)	D-O	0.75 (20)	D-O	1.5 (40)	D-K-O	2.5 (65)	D-K-O	3.5 (90)
PACKAGED STEAM GENERATIONS (Boilers)	A-P	0.35 (9)	D-P	0.75 (20)	D-P	0.75 (20)	D-P	1.5 (40)	D-P	2.5 (65)
PUMPS										
Close Coupled										
Through 5 hp (4 kw)	A-L-O	0.35 (9)	B-L-O	0.75 (20)	B-L-O	0.75 (20)	B-L-O	1.5 (40)	B-L-O	1.5 (40)
7-1/2 hp (5.6 kw) and Larger	B-L-O	0.75 (20)	B-L-O	0.75 (20)	B-L-O	1.5 (40)	B-L-O	1.5 (40)	B-L-O	2.5 (65)
Base Mounted										
Through 60 hp (45 kw)	B-L-O	0.75 (20)	B-L-O	0.75 (20)	B-L-O	1.5 (40)	B-L-O	1.5 (40)	B-L-O	2.5 (65)
75 hp (56 kw) and Larger	B-L-O	0.75 (20)	B-L-O	1.5 (40)	B-L-O	2.5 (65)	B-L-O	2.5 (65)	B-L-O	3.5 (90)
FACTORY ASSEMBLED H & V UNITS										
Fan Coil Units (Unit Heaters)	F	0.75 (20)	F	0.75 (20)	F	0.75 (20)	F	0.75 (20)	F	0.75 (20)
Curb Mounted Rooftop Units	---	---	M	0.75 (20)	N	1.5 (40)	N	2.5 (65)	N	2.5 (65)
Suspended Units (for Fan Heads see Blowers Guide)										
Through 5 hp (4 kw)	F	0.75 (20)	F	0.75 (20)	F	0.75 (20)	F	0.75 (20)	F	0.75 (20)
7-1/2 hp (5.6 kw) and Larger - 275 rpm to 400 rpm	F	1.5 (40)	F	1.5 (40)	F	1.5 (40)	F	1.5 (40)	F	1.5 (40)
7-1/2 hp (5.6 kw) and Larger - 401 rpm and Over	F	0.75 (20)	F	0.75 (20)	F	0.75 (20)	F	1.5 (40)	F	2.5 (65)
Floor Mounted Units (for Fan Heads see Blowers Guide)										

	ISOLATION AND DEFLECTION CRITERIA FOR 4" (100mm) THROUGH 6" (150mm) THICK SOLID CONCRETE FLOORS (Notes 6 & 7)									
	Ground Supported Slab or Basement		20' (6m) Floor Span Possible Floor Defl.-0.67" (17mm)		30' (9m) Floor Span Possible Floor Defl.-1.0" (25mm)		40' (12m) Floor Span Possible Floor Defl.-1.33" (34mm)		50' (15m) Floor Span Possible Floor Defl.-1.67" (42mm)	
	Isolation Spec.	Isol. Defl. in.(mm)	Isolation Spec.	Isol. Defl. in.(mm)	Isolation Spec.	Isol. Defl. in.(mm)	Isolation Spec.	Isol. Defl. in.(mm)	Isolation Spec.	Isol. Defl. in.(mm)
Through 5 hp (4 kw)	A	0.35 (9)	B	0.75 (2)	B	0.75 (20)	B	0.75 (20)	B	0.75 (20)
7-1/2 hp (5.6 kw) and Larger - 275 rpm to 400 rpm	A	0.35 (9)	B	1.5 (40)	B	1.5 (40)	B	1.5 (40)	B	1.5 (40)
7-1/2 hp (5.6 kw) to 40 hp - 401 rpm and Over	A	0.35 (9)	B	0.75 (20)	B	0.75 (20)	B	1.5 (40)	B-K	2.5 (65)
50 hp (38 kw) and Larger - 401 rpm and Over	A	0.35 (9)	B	0.75 (20)	B	1.5 (40)	B-K	2.5 (65)	B-K	3.5 (90)
AIR COMPRESSOR										
Tank Mounted Type	B-L-P	0.75 (20)	B-L-P	0.75 (20)	B-L-P	1.5 (40)	B-L-P	2.5 (65)	B-L-P	3.5 (90)
V - W Type	B-L-P	0.75 (20)	B-L-P	0.75 (20)	B-L-P	1.5 (40)	B-L-P	2.5 (65)	B-L-P	3.5 (90)
Horiz, Vert, 1 or 2 Cylinders (Note 4)										
275 rpm to 499 rpm	B-L†-P	2.5 (65)	B-L†-P	2.5 (65)	B-L†-P	2.5 (65)	B-L†-P	3.5 (90)	B-L†-P	3.5 (90)
500 rpm to 800 rpm	B-L†-P	1.5 (40)	B-L†-P	1.5 (40)	B-L†-P	2.5 (65)	B-L†-P	3.5 (90)	B-L†-P	3.5 (90)
	† 'L' specification, in this section only, should read 'L' type inertia bases with sufficient mass to limit motion to a theoretical double amplitude of 0.03" (.7mm).									
BLOWERS	Engineering Specifications and Minimum Static Deflection as tabulated below (Note 1)									
Utility Sets										
Floor Mounted (Note 5)	A	0.35 (9)	Spec B for 0.75" (20mm) and 1.5" (40mm) deflection and Spec B-L for over 1.5" (40mm) deflection with deflection from Blower Minimum Deflection Guide below, but not to exceed 2.5" (65mm).							
Roof Mounted	---	---	Spec B-L with deflection from Blower Minimum Deflection Guide below. If roof will not handle concrete base load, use Spec D for 0.75" (20mm) and 1.5" (40mm) deflection and Spec D-K for over 1.5" (40mm) deflection.							
Suspended Unit (Note 5)	---	---	Spec F with deflection from Blower Minimum Deflection Guide below, not to exceed 2.5" (65mm) deflection.							
Centrifugal Blowers (Note 6)	A-L	0.35 (9)	Spec B-L with deflection from Blower Minimum Deflection Guide below.							
Fan Heads (HVAC Unit Blower Section Only)										
Floor Mounted	A-I	0.35 (9)	Spec B-I if 0.75" (20mm) or 1.5" (40mm) deflection or Spec B-K-I for deflection over 2.5" (65mm) to 4.5" (115mm) from Blower Minimum Deflection Guide below.							
Suspended Units	Spec F-I with deflection from Blower Minimum Deflection Guide below.									
Tubular Centrifugal and Axial Fans										
Suspended Units	Spec F with deflection from Blower Minimum Deflection Guide below, Spec F-I for over 4" (100mm) static pressure.									
Floor Mounted with Motor on/in Fan Casing	A	0.35 (9)	Spec B for 0.75" (20mm) and 1.5" (40mm) deflection and Spec B-K-I for 2.5" (65mm) to 4.5" (115mm) deflection with deflection from Blower Minimum Deflection Guide below, Spec B-L-I or B-I for over 4" (100mm) static pressure.							
Floor Mounted Arrangement 1 or any Separately Mounted Motor	A-L	0.35 (9)	Spec B-L with deflection from Blower Minimum Deflection Guide below.							
COOLING TOWERS & CONDENSING UNITS	A	0.35 (9)	Spec D with deflection from Blower Minimum Deflection Guide below.							

BLOWER MINIMUM DEFLECTION GUIDE

When blowers are 60 hp (45 kw) or larger, select deflection requirements for next larger span. A minimum of 2.5" (65mm) should be used unless larger deflections are called for on the chart or these fans are located in the lowest sub-basement or on a slab on grade

Fan Speed RPM	Required Deflection for Ground Supported Slab or Basement	Required Deflection for 20' (6m) Floor Span	Required Deflection for 30' (9m) Floor Span	Required Deflection for 40' (12m) Floor Span	Required Deflection for 50' (15m) Floor Span
500 and Up	0.35" (9mm)	0.75" (20mm)	1.5" (40mm)	2.5" (65mm)	3.5" (90mm)
375 - 499	0.35" (9mm)	1.5" (40mm)	2.5" (65mm)	3.5" (90mm)	3.5" (90mm)
300 - 374	0.35" (9mm)	2.5" (65mm)	2.5" (65mm)	3.5" (90mm)	3.5" (90mm)
225 - 299	0.35" (9mm)	3.5" (90mm)	3.5" (90mm)	3.5" (90mm)	3.5" (90mm)
175 - 224	0.35" (9mm)	3.5" (90mm)	4.5" (115mm)	4.5" (115mm)	4.5" (115mm)

VIBRATION ISOLATOR SCHEDULE

Equipment or Pipe Description	Design Deflect.	Isolator Type	Frame Type	Remarks
Chilled, Condenser & Heating Water Piping (1" & Larger):				
X Within 30' from Fan Coil Units	1"	B or F	---	
X Within 30' from Air Handlers	.35"	D or G	---	
X Remaining Piping Beyond 30" from Unit	1"	Q2	---	
X Wall or Floor Pipe Penetrations	---	Q	---	
X Riser Clamps	---	D2	---	
Chilled, Condenser & Heating Water Piping (Less Than 1"):				
X Within 30' from Equipment	.35"	D or G	---	
X Remaining Piping Beyond 30'	---	Q2	---	
X Wall or Floor Penetrations	---	Q	---	
X Riser Clamps	---	R	---	
Pipe Connections at Vertical In-Line Pumps	---	None	---	
Pipe Connection at Chiller & Heat Exchanger	---	None	---	
Plumbing Piping:				
X Domestic Hot and Cold Water Piping Within 30' of Circ. Pump	0.2"	F1	---	
X Domestic Hot and Cold Water Piping Remaining Beyond 30'	---	Q2	---	
X Riser Clamps	---	R	---	

VIBRATION ISOLATOR SCHEDULE				
Equipment or Pipe Description	Design Deflect.	Isolator Type	Frame Type	Remarks
X Wall or Floor Pipe Penetrations (Pipes 1" and Larger)	---	Q	---	
X Wall or Floor Pipe Penetrations (Pipes less than 1")	---	Q2	---	

2.3 GENERAL REQUIREMENTS PRIOR TO INSTALLATION

A. Examine areas and conditions under which vibration control units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to installer.

B. Prior to installation of vibration isolators, frames, guides and related materials, the following conditions shall be met:

1. All submittals for equipment shall be approved by the Architect.

2. Written and oral instructions from the vibration isolation equipment manufacturer shall be obtained.

3. Any conflicts between trades resulting in unavoidable rigid contact of vibrating equipment piping or ductwork due to inadequate space or other unforeseen conditions shall be brought to the Architect's attention. If these conflicts are not resolved before installation, all corrective work shall be at the Contractor's expense.

4. Any discrepancies between the specifications and field conditions or any changes due to specific equipment selection shall be brought to the Architect's attention. If these discrepancies are not resolved before installation, all corrective work shall be at the Contractor's expense.

2.4 GENERAL REQUIREMENTS FOR INSTALLATION

A. Furnish and install vibration isolators, bases and related materials and insure the following:

1. No mechanical equipment or piping shall make rigid contact with the "building" unless it is approved in this specification or by the Architect. "Building" includes, but is not limited to, roofs, floors, beams, columns, walls, partitions, ceilings, studs, ceiling framing and suspension systems. Space all vibration-isolated equipment and isolated components and all vibration isolators (including rods and wires) so as to be entirely free of any contact with any building element in any reasonable operating position.

2. The installation or use of vibration isolators shall not cause any change of position of equipment, piping or ducts that results in stresses in any

connections or misalignment of shafts or bearings. In order to meet this objective, equipment, piping and ducts shall be maintained in a rigid position during installation. The load shall not be transferred to the isolators until the installation is complete and in operational condition.

3. No equipment unit shall bear directly on or be suspended from vibration isolators or brackets unless its own frame or casing is suitably rigid to span between isolators without any significant or noticeable deformation and such support is approved by the manufacturer.

4. General: Except as otherwise indicated, comply with manufacturer's instructions for installation and load application to vibration control materials and units. Adjust to ensure that units have equal deflection, do not bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices intended for temporary support during installation.

5. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces, and as indicated.

6. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.

2.5 INSTALLATION OF FLOOR- AND ROOFTOP-MOUNTED EQUIPMENT

A. Provide vibration isolation for base-mounted equipment as scheduled and per all instructions in this specification.

B. Unless otherwise shown or specified, all base-mounted equipment shall be set on 4-inch thick, hardrock concrete housekeeping pads. Vibration isolators shall be bolted to the housekeeping pad. The pad dimensions shall exceed the equipment footprint (including floor mounts) by at least 12" in each direction (i.e., 6" per side).

C. Unless otherwise indicated, a minimum clearance of 1 inch shall be provided between the top of a housekeeping pad, floor, or roof, and the underside of an equipment unit or steel base frame that is vibration-isolated. Where a concrete inertia block is used, the minimum clearance shall be 2" or 3% of the base's smaller dimension, whichever is larger. This space shall be cleaned thoroughly of all dirt and debris.

D. For isolation equipment (Styles B and C) with neoprene pads bearing directly on structure, fasten the isolator base plates to the building structure with suitable bolts. Isolate steel bolts from steel base plates with neoprene bushings or washers and sleeves (Style D3) minimum 1/4-inch thick and maximum 40-durometer hardness. Provide steel washers to distribute bolt head loads to neoprene bushings or washers below. Size bolt holes in isolator bases to account for neoprene bushings or sleeves.

E. All bases for pumps shall be of sufficient area to support any required pipe stanchions below pipe elbows.

F. Bases for boilers shall be of sufficient area to support draft fans, if included.

G. Fans and pumps and their respective motors shall always be mounted on a common base.

H. Chillers shall be resiliently isolated from the structure by means of vibration isolators provided between suitably framed grillage and dunnage steel or building structure. The isolators shall be adjusted to carry the chiller load resiliently.

I. Wind loads shall be accounted for in rooftop installations, including appropriate snubbers and slack-cable restraints.

2.6 INSTALLATION OF CEILING- AND ROOF-SUSPENDED EQUIPMENT

A. Provide vibration isolation for suspended equipment as scheduled and per all instructions within this specification.

B. Ceiling- or roof-suspended equipment shall be supported from the heaviest possible structure, such as trusses, girders, beams, or joists. If necessary, provide heavy extra sub-structure between the building's existing heavy structure in order to support vibration-isolated equipment. Do not suspend equipment from roof decks or floors without approval of the Architect. Connect vibration isolation hangers directly to, or as close as possible to, heavy structure.

C. Hanger rods shall be aligned and free of contact with hanger boxes.

D. Fans and their respective motors shall always be suspended on a common, stiff frame.

2.7 INSTALLATION OF RESILIENT DUCT SUPPORTS

A. Provide resilient support of ducts in locations and on isolators as scheduled and/or as shown on the drawings.

2.8 INSTALLATION OF RESILIENT PIPE SUPPORTS

A. Unless otherwise specified, provide resilient support for all HVAC and plumbing water pipes throughout the building. No such piping is to come into rigid contact with the building.

B. Where "piping systems" are required to be vibration-isolated in a certain room or for a certain distance from an equipment unit, "piping systems" shall include all pipes, valves, strainers, tanks and other connected hardware.

C. Vibration isolate all piping within 30 feet of equipment in accordance with the Vibration Isolation Schedule.

D. Throughout the rest of the building not covered in Paragraph C above, use M2 resilient pipe sleeves for support. An alternate to this is 1-inch-thick, 10-PCF-density glass fiber pipe insulation with suitable bearing plates to prevent crushing of insulation and without any steel pin or other rigid connection from plate to pipe through insulation.

E. Provide Style M2 or M or custom resilient pipe sleeves wherever pipes penetrate construction.

F. Provide Style N resilient pipe anchor/guide where anchors and/or guides are required in horizontal and vertical piping. Connect N units to heavy structure only.

G. Release restraining washers and nuts in order to “free” all pre-compressed spring hangers.

H. Riser Isolation: Risers shall be suspended from or supported by Style D1 hangers or Style A mounts and the piping anchored or guided with Style N anchors. Neoprene hanger and mount deflections shall be a minimum of 0.30", except in those expansion locations where additional deflection is required to limit riser deflection or load changes to ∀25% of the initial stress. In these cases, Style E hangers or Style C mounts shall be used in lieu of neoprene isolators, for a minimum distance of 20 feet upstream and downstream of the expansion loops.

I. Weld riser isolator units in place as required to prevent displacement loading and operations.

2.9 INSTALLATION OF RESILIENT PIPE CONNECTIONS TO EQUIPMENT

A. For all pipe connections to equipment, any flexible connector approved by the Architect is acceptable.

B. Flexible Pipe Connectors: Install on equipment side of shutoff valves, horizontally and parallel to equipment shafts wherever possible.

2.10 INSTALLATION OF RESILIENT DUCT CONNECTIONS TO EQUIPMENT

A. Provide flexible connections between ducts and all vibrating equipment. Use neoprene-impregnated fabric material unless loaded vinyl is specifically scheduled.

B. Align sheet-metal duct with fan or fan casing opening in all three dimensions prior to installation of flexible connection so that duct and opening nearly coincide and are almost equally spaced 3 inches from one another all around. Do not install flexible connection until above requirements are met. Fans or fan casings and ducts shall be able to move 1 inch in any direction relative to each other without short-circuiting metal-to-metal- or stretching taut the flexible connection.

2.11 INSTALLATION OF RESILIENT AND AIRTIGHT SLEEVES

A. Styles M, M2 and M3 Resilient Pipe Sleeves: Observe requirements in **Paragraphs 3.8A and 3.8B above**. In lieu of packing and sealant, clamp factory-fabricated sleeve assemblies tightly around penetrating elements, using built-in or field-supplied clamping devices. Apply clamping of sleeves to penetrating services before sealing of sleeves to penetrated constructions.

B. Custom Sleeves:

1. Cut a clean opening in the penetrated construction very nearly the size of the sleeve for each penetrating element. Provide lintels above, relief structure below, and vertical framing between and to the sides as required. Provide the above, escutcheon plates, and anything else necessary to make the penetrated structure as solid and massive near the penetrations as away from the penetrations.

2. Set the metal sleeve into the penetrated construction in an airtight manner around its outer periphery, using grout, dry packing, plaster, or drywall compound full depth and all around (but only to a maximum width of 1 inch) or the requirements of the above paragraph shall not have been satisfied.

3. Pack the 1/2-inch wide annular opening with glass fiber between metal sleeve and penetrating element full depth all around to a firm degree of compaction. Leave a 1/2-inch deep annular opening free at each end of the metal sleeve; fill this fully with acoustical sealant.

2.12 PERFORMANCE OF ISOLATORS

A. General: Comply with minimum static deflections indicated in the Vibration Isolation Schedule for selection and application of vibration isolation materials and units as indicated.

B. Manufacturer's Recommendations: Except as otherwise indicated, comply with manufacturer's recommendations for selection and application of vibration isolation materials and units.

2.13 APPLICATIONS

A. General: Except as otherwise indicated, select vibration control products in accordance with ASHRAE Handbook, Systems Volume, Chapter 35, "Sound and Vibration Control," Table 45. Where more than one type of product is offered, selection is installer's option.

B. Piping: For piping connected to equipment mounted on vibration control products, install isolation hangers as indicated and for first three points of support for pipe sizes 4" and less, for first four points of support for pipe sizes 5" through 8", and for first six points of support for pipe sizes 10" and over.

2.14 ADJUSTING AND CLEANING

A. Upon completion of vibration control work, prepare report showing measured equipment deflections for each major item of equipment as indicated.

B. Clean each vibration control unit, and verify that each is working freely and that there is no dirt or debris in immediate vicinity of unit that could possibly short-circuit unit isolation.

END OF SECTION

SECTION 23 05 93

HVAC SYSTEM TESTING, ADJUSTING, AND BALANCING

PART 1 GENERAL

1.1 QUALIFICATIONS

A. Agency Qualifications: The independent TAB Agency shall be a current member of the Associated Air Balance Council (AABC) or a National Environmental Balancing Bureau (NEBB) certified contractor with Louisiana recognition.

PART 2 DESIGN STANDARD

2.1 GENERAL

A. The specified systems shall be reviewed and inspected for conformance to design documents. Testing, adjusting and balancing on each identified system shall be performed. The accuracy of measurements shall be in accordance with AABC or NEBB National Standards. Adjustment tolerances shall be within 10% unless otherwise stated.

B. Equipment settings, including manual damper quadrant positions, manual valve indicators, fan speed control levers, and similar controls and devices, shall be marked to show final settings.

C. Balance shall include both air and wet side balance.

D. Submit TAB trade subcontractor’s qualifications and equipment certifications prior to awarding contract to TAB. Owner reserves the right to review and require updating or request alternate TAB contractors should qualifications or equipment be found insufficient in the owner’s sole discretion.

E. Submit a TAB plan including project specific TAB procedures, forms, and drawings to be used. TAB plan and procedures shall be performed per AABC or NEBB standard protocols.

F. Submit the TAB Preliminary Field Reports to the Commissioning Agent and Engineer for review and approval prior to the Final Report. Commissioning Agent will provide back-checking of some portion of TAB results.

2.2 ADDITIONAL TAB AGENCY SERVICES

A. The TAB Agency shall provide the following additional services:

1. Fire and Smoke Testing: The TAB Agency shall test fire/smoke dampers to assure operation, and verify that an access door has been installed for each fire and smoke damper.

2. Life Safety Controls: The TAB Agency shall test and record life safety control operation on the HVAC equipment. The Agency shall verify the installation of required smoke detectors in air handling equipment (AHE), and shall verify operation of the smoke detector by activating the smoke detector and observing air handler shutdown.

3. Engine Generators: The TAB Agency shall test and verify the air flow through each engine generator set at the outlet duct from the generator. The test shall be conducted with two generators running, the garage grate door closed, and the general garage exhaust fan off to simulate a typical emergency event. The generator air flow at each of the three generators shall be measured and reported.

4. Warrantee Period Trouble Shooting Services: The TAB Agency shall provide the senior technician who completed the facility TAB report field testing to attend up to six warrantee period trouble shooting meetings on site at the request of the engineer. Such meetings may be arranged to be attended jointly with the engineer, controls contractor, and/or the mechanical contractor to jointly assist in trouble shooting activities and to assist in the remedy of any building HVAC system operational difficulties. Such meetings may require additional adjustments or modification of settings, sequences of operation, and similar refinements to obtain the best possible performance of the HVAC systems. Minor adjustments requested by the owner or others shall not be included in the count of six trouble shooting meetings. For any of the six meetings the TAB contractor shall be prepared with tools and equipment necessary to adjust, test, and balance systems as directed by the engineer.

END OF SECTION

SECTION 23 07 00

DUCT AND PIPE INSULATION

PART 1 GENERAL

1.1 SUMMARY – INSULATION FOR DUCTS AND HVAC PIPING

A. All insulation material, coverings, adhesives, vapor barriers, and tapes shall have a flame spread classification not to exceed 25 and a smoke development not to exceed 50 in accordance with NFPA 90A.

B. Insulation shall meet or exceed minimum 2007 ***ASHRAE 90.1*** requirements.

C. Insulation will be continuous, without gaps or open seams. Insulation will be pre-formed to fit tightly around pipe. Insulation will be pre-formed to fit tightly around fittings, valves, and appurtenances.

D. Insulation will be provided with a continuous jacket vapor barrier without gaps or open seams: PVC jackets will be used indoors and aluminum jackets will be used outdoors. Vapor barrier will be continuous, sealed vapor tight, adhered seams indoors and caulked seams outdoors.

E. Insulation and vapor barriers with open seams, leaks, or similar shall be rejected and reworked by the contractor to the satisfaction of the Engineer at no cost to the Owner.

1.2 ACOUSTICAL DUCT INSULATION

A. Scope: Refer to Duct Construction and Duct Insulation Requirements Table on Sheet M050 for requirements for each type of duct.

B. Material:

1. Supply and return ductwork shall have a minimum R-6 rating for 1-1/2” thick insulation and a R-8 rating for 2” thick insulation. Not less than an NRC of 1.0 for 2" duct liner, .70 for 1-1/2" duct liner and .55 for 1/2" duct liner, coated to a smooth finish. Duct liner shall meet the requirements of NFPA 90A and be so labeled, suitable for velocities no less than 4,000 fpm.

1.3 THERMAL DUCT INSULATION - CONCEALED DUCTS & PLENUMS

A. Refer to Duct Construction and Duct Insulation Requirements Table on Mechanical Plans for requirements for each type of duct. Insulation shall meet or exceed minimum 2007 ASHRAE 90.1 requirements.

1.4 PIPING INSULATION

A. Chilled Water Piping:

1. Work specified herein

a. Provide all labor, materials, equipment and services necessary to insulate all chilled and refrigerant piping complete as indicated or specified. All insulation shall be furnished and installed by a licensed, approved insulation contractor.

b. Pipe insulation shall conform to the requirements of the International Energy Conservation Code 2012, shall be tested in accordance with ASTM 84 and shall have a maximum flame spread index of 25 and a smoke-developed index not exceeding 50.

2. Thickness

a. insulation shall have thermal characteristics equivalent to the following:
1) Piping 3/4"ø to 1-1/2"ø = 1" thick
2) Piping 2"ø to 6”ø = 1-1/2" thick.
Values Above based on having a conductivity (k) not exceeding 0.27 btu / inch / hour - s.f. - °f)

3. Above ground

a. Material

1) Fiberglass: dual temperature pre-molded fiberglass insulation maximum k = 0.24 at 75 f, minimum 3.5 pound density, with PVC Jacket and PVC fitting Covers. PVC jacket shall be used at interior of building only. Aluminum jacket shall be used for pipe/insulation outdoors and exposed to weather.

b. Application

1) Fiberglass: Coat underside of longitudinal laps and 4" wide transverse stripping tape with vapor barrier adhesive and staple through adhesive 3" o.c. concealed fittings, valves, etc., shall be covered with Zeston or equal fitting covers with all seams sealed with adhesive - no staples. All Zeston fitting covers shall be packed full of fiberglass insulation, maximum k = 0.33. Cover exposed fittings, valves, etc, with insulation and ¼" hard finish plastic cement, covering material, and lagging adhesive. Provide hard sections at all hangers, minimum 12" long.

2) Cellular plastic: Install insulation by slitting tubular sections and applying over piping or sliding the tubing, un-slit, over the end of the piping. Fabricate miter cut covers for fittings from insulation in conformance with manufacturer's recommendations. Seal joints and butt ends with fire retardant, waterproof adhesive equal to Armstrong 520. (Taped joints will not be accepted.) Finish all pipe insulation exposed to weather with aluminum jacket.

3) Hangers and rollers: 180 degree, 20-gauge galvanized steel shield banded in place with two ¼" bands, 6" long to 1-1/2" pipe, 12" long 2" and over. Install 180 degree hard sections same length as shield at each hanger.

4) Hard sections: Hydrous calcium silicate shall be provided between shield and pipe. Maximum k factor = .24

4. Exposed to weather

a. Scope: Provide heat tape and thermostat set per controls specification. Install tape in accordance with manufacturer's recommendations.

b. Cover all piping and fitting exposed to weather with aluminum jacket, sealed weather tight.

c. Material: Corrugated or smooth 0.017" aluminum with Polykraft moisture barrier factory attached, snap seal longitudinal seams.

d. Fitting & valve covers: all aluminum minimum 0.016" thick, pre-molded and shaped to the valve or fitting.

e. Bands: minimum 0.016" thick, 2" wide, stainless steel snap-straps, max 24" o.c. or 0.010 thick, 1" wide, 12" o.c.

B. Hot Water Piping:

1. Work specified herein

a. Provide all labor, materials, equipment and services necessary to insulate all chilled water and hot water piping complete as indicated or specified. All insulation shall be furnished and installed by a licensed, approved insulation contractor.

b. Pipe insulation shall conform to the requirements of the international energy conservation code, shall be tested in accordance with astm 84 and shall have a maximum flame spread index of 25 and a smoke-developed index not exceeding 50.

2. Thickness

a. Insulation shall have thermal characteristics equivalent to the

following:

1) Piping 3/4"ø to 1-1/2"ø - 1" thick
2) Piping 2"ø to 6ø - 1-1/2" thick.
   The above is based on having a conductivity (k) not exceeding 0.27 btu / inch / hour - s.f. - °f

3. Above ground

a. Material

1) Fiberglass: dual temperature pre-molded fiberglass insulation maximum k = 0.24 at 75 f, minimum 3.5 pound density, asj jacket.

b. Application

1) Fiberglass: coat underside of longitudinal laps and 4" wide transverse stripping tape with vapor barrier adhesive and staple through adhesive 3" o.c. concealed fittings, valves, etc., shall be covered with Zeston or equal fitting covers with all seams sealed with adhesive - no staples. All Zeston fitting covers shall be packed full of fiberglass insulation, maximum k = 0.33. Cover exposed fittings, valves, etc, with insulation and ¼" hard finish plastic cement, covering material, and lagging adhesive. Provide hard sections at all hangers, minimum 12" long.

2) Cellular plastic: Install insulation by slitting tubular sections and applying over piping or sliding the tubing, unslit, over the end of the piping. Fabricate miter cut covers for fittings from insulation in conformance with manufacturer's recommendations. Seal joints and butt ends with fire retardant, waterproof adhesive equal to Armstrong 520. (Taped joints will not be accepted.)

3) Hangers and rollers: 180 degree, 20-gauge galvanized steel shield banded in place with two ¼" bands, 6" long to 1-1/2" pipe, 12" long 2" and over. Install 180 degree hard sections same length as shield at each hanger. Provide hard section between shield and pipe.

4) Hard sections: Hydrous calcium silicate shall be provided between shield and pipe. Maximum k factor = **0.37 (reference detail *15 and* 16 sheet *M600*).**

(END OF SECTION)

SECTION 23 08 39

AIR HANDLING AND AIR DISTRIBUTION SPECIALTIES

PART 1 GENERAL

1.1 SUMMARY

A. Furnish and install all air outlets, dampers, etc., as shown on the drawings and herein specified. Each unit must be designed for the service intended, of the size and capacities indicated, and complete with all accessories as noted.

PART 2 DESIGN STANDARD

2.1 GRILLES, REGISTERS, DIFFUSERS

A. All grilles, registers, and diffusers in shower rooms and locker rooms shall be all aluminum construction.

B. Ceiling Damper Operators: Provide a Young #315 or equal concealed damper operator for all dampers located in inaccessible locations. Provide cover plate at ceiling.

2.2 LOUVERS

A. Furnish and install louvers as indicated on the drawing and herein specified.

B. Construction: Louvers shall be extruded aluminum construction, frame depth, drainable, expanded, flatted aluminum bird screen in removable frame on interior face and *equal to that specified on plans*. Finish as directed by the Architect. Provide free area guide with submittal.

2.3 BACKDRAFT DAMPERS

A. Furnish and install counter-balanced backdraft dampers as indicated on the drawings and herein specified.

B. Construction: Dampers shall be aluminum with .090" thick channel frame and .025" thick blades with extruded vinyl edge seals. Linkage shall be aluminum concealed in the frame and bearings shall be nylon. Leakage shall not exceed 15 CFM per square foot at 1" WG. Damper shall be equal to *as specified on plans.*

C. Operation: Damper shall be capable to operate in the range of 0.01” w.g. to 0.05” w.g. over the entire range of airflow (0.01”w.g. start open to 0.05”w.g. full open *unless specified otherwise on plans*). Dampers that are not capable of operating within this range are not acceptable.

END OF SECTION

SECTION 23 08 39

AIR HANDLING AND AIR DISTRIBUTION SPECIALTIES

PART 1 GENERAL

1.1 SUMMARY

A. Furnish and install all air outlets, dampers, etc., as shown on the drawings and herein specified. Each unit must be designed for the service intended, of the size and capacities indicated, and complete with all accessories as noted.

PART 2 DESIGN STANDARD

2.1 GRILLES, REGISTERS, DIFFUSERS

A. All grilles, registers, and diffusers in shower rooms and locker rooms shall be all aluminum construction.

B. Ceiling Damper Operators: Provide a Young #315 or equal concealed damper operator for all dampers located in inaccessible locations. Provide cover plate at ceiling.

2.2 LOUVERS

A. Furnish and install louvers as indicated on the drawing and herein specified.

B. Construction: Louvers shall be extruded aluminum construction, frame depth, drainable, expanded, flatted aluminum bird screen in removable frame on interior face and *equal to that specified on plans*. Finish as directed by the Architect. Provide free area guide with submittal.

2.3 BACKDRAFT DAMPERS

A. Furnish and install counter-balanced backdraft dampers as indicated on the drawings and herein specified.

B. Construction: Dampers shall be aluminum with .090" thick channel frame and .025" thick blades with extruded vinyl edge seals. Linkage shall be aluminum concealed in the frame and bearings shall be nylon. Leakage shall not exceed 15 CFM per square foot at 1" WG. Damper shall be equal to *as specified on plans.*

C. Operation: Damper shall be capable to operate in the range of 0.01” w.g. to 0.05” w.g. over the entire range of airflow (0.01”w.g. start open to 0.05”w.g. full open *unless specified otherwise on plans*). Dampers that are not capable of operating within this range are not acceptable.

END OF SECTION

SECTION 23 09 00

CONTROLS
(BACNet)

GENERAL

DESCRIPTION

This section defines the basic materials and methods used in the installation of BACNet Building Automation System (BAS) control products to provide the functions necessary for control of the mechanical and other specified systems on this project.

The Building Automation System (BAS) is to provide a peer-to-peer networked, stand-alone, distributed control system for building mechanical, electrical, plumbing, generator sets per plans and specifications. The BAS system shall also receive information from the fire protection and fuel level and alarm (FP-1) systems per plans. The BAS shall include an operator workstation also known as Engineering Control Center (ECC), microprocessor based control units panels, all instrumentation end control devices, all wiring, all rigid metal conduit per NEC 708, all transformers, and all miscellaneous devices and related systems to provide centralized and facility wide control functions per plans. The ECC shall be located at the desk located just adjacent to the mechanical and ups rooms.

The BAS shall be designed such that each mechanical, electrical, plumbing, fuel and fire alarm system will be able to operate under stand-alone control. As such, in the event of a network communication failure, or the loss of any other controller, the sub-control systems shall continue to independently operate under their own local control.

The BAS system shall utilize a separate Ethernet network installed by the control contractor. The main GC/LAN controller shall connect into the owners WAN and utilize a separate VPN for IP communication.

Within the building the control contractor shall install wireless LAN nodes to his network so the operators can communicate with the system wirelessly within the building

Alarmable points and required data trends and reports shall be coordinated during the submittal process with Owner automation staff.

Special Control Systems:

Upon detection of fire in the building all OSA intakes shall close including the AFM-1 and AFM-2 unit until a software manual reset is accomplished.

In the 911 call center provide a special OSA control over-ride allowing the Supervisor to close OSA intakes (AFM-1, AFM-2) to the building and shutdown exhaust fans as indicated in the control sequence of operations for emergency situations such as gas release, bombs, etc. near the building. The over-ride

should be a special manual switch with a ID plate “Outside Air Over Ride- On – Off” The switch shall have a break-glass cover.

FIRE PROTECTION ENGINEER INTERFACE AND COORDINATION

As this is a mission critical facility the controls contractor shall include coordination and interface with the Fire Protection Engineer to assure all required sequences of operation are integrated and programmed properly. A tie between the BAS and the Fire Alarm Control panel, engine generator control systems, plumbing devices, gen set fuel tanks, and fuel level system FP-1 shall be established in BACnet protocol and data exchange and sequences confirmed and coordinated. Refer to Specification Section 21 for understanding of this role.

DEFINITIONS

Application Specific Controller (ASC): A networked device that contains a complete, configurable application that is specific to a particular task. Also known as Unitary Controller (UC). This application is normally produced by the device manufacturer and contains a number of configuration parameters that may be adjusted by network tools.

BACnet: ANSI/ASHRAE Standard 135–2001. A data communication protocol for Building Automation and Control Networks. Created by ASHRAE SPC135.

Building Automation System (BAS): The facility control system comprised of mechanical system automation, automatic temperature control, etc., as defined in the contract documents. This infrastructure may include field wiring, LAN wiring, routers, bridges, raceways, and gateways as required connecting non-interoperable subsystems and devices.

Control Wiring: Includes conduit, wire and wiring devices to install a complete Control System including motor control circuits, interlocks, thermostats, PE and EP switches and like devices. Includes all wiring from a DDC cabinet to all sensors and points defined in the Points List summary or specified herein and required to execute the sequence of operation. Includes necessary power wiring to all BAS devices, digital controllers including terminal units and actuators.

Note: All Critical Operations Power System and Control Wiring shall be installed in rigid metal conduit in strict accordance with NEC 2008 ARTICLE 708.

Operator Interface: A device (PC, laptop or dumb display terminal) which incorporates Application Program Interface (API) for remote network client services. The operator interface workstation may connect to an IP network. A GUI is graphical subset of Operator interfaces.

CODES and STANDARDS

Agency Listings

All products of the BAS shall be provided with appropriate agency approvals. With the submittal documents, verification that the approvals exist for all

submitted products shall be provided. Systems or products not currently offering one or more of the following approvals are not acceptable:

UL-916; Energy Management Systems

UL-873; Temperature Indication and Regulating Equipment

UL-864, Subcategories UUKL, UOXX, UDTZ; Fire Signaling and Smoke Control Systems

FCC, Part 15, Subpart J, Class A Computing Devices Emissions Requirements Code Approvals

NEC 2008 ARTICLE 708 Critical Operations Power Systems (COPS)

DESIGN STANDARD

ACCEPTABLE CONTROL CONTRACTORS

Control Contractors (BACNet): Siemens, Alerton (Climatec), Johnson Controls.

COMMUNICATIONS NETWORK, PC, AND MODEM SUPPORT

Provide one (1) PC workstation EEC complete with PC, 24” flat panel screen, keyboard, wireless mouse, NIC card and software to provide onsite monitoring and control of the BAS system. Provide (1) color inkjet printer. Provide all required software for specified control sequence and graphics as specified. The computer shall be equal to the current top of the line desktop computer for general business use from Dell Computer. The printer shall be equal to the top of the line HP Inkjet printer for 100 Page capacity 8.5” x 11”.

Provide (1) Laptop computer work tool complete with all required programming tools and the capability to view all IP graphics. Laptop shall be capable of communicating to the system over the wireless network. Laptop shall be equal to the current top of the line Laptop for general business use from Dell Computer.

Provide software and programming for offsite monitoring and control from authorized Owner staff as required for complete remote control and communications.

Provide all hardware and software necessary to allow remote communications via modem to off-site locations. The off-site locations shall be able to communicate with the remote site system even if the remote PC is turned off or not functioning.

All systems must comply with a Class 3 conformance level of the BACnet specification with 802.3 compliant communications systems. This is a Tier-1 level compliance. Failure to document the proposed DDC system’s conformance will result in the rejection of the contractors bid.

The control contractor shall provide all hardware, control devices, software, logic programming, and graphic programming to facilitate the implementation of the sequence of control as detailed on the contract control drawings. The contractor

shall be responsible to add or enhance any control hardware or software that is required to achieve the specified system and its sequence of control.

The BAS shall have a complete commissioning and point to point testing.

System Controllers, Field Panels, Local Controllers, Global Controllers, Etc.

Global LAN Controller Panel (GC/LAN)

The GC/LAN Controller shall utilize the BACnet protocol on the Management level Ethernet media. The LAN controller shall at a minimum provide a Class 3 conformance level of the BACnet specification with 802.3 compliant communications systems. The GC/LAN shall communicate with BACnet Operator Workstations, other BACnet GC/LAN controllers and third party BACnet equipment to create a fully operational BAS.

Building Controller shall as a minimum support Ethernet BACnet LAN types. It shall communicate directly via the BACnet LANs as a native BACnet device. Global controller shall be a BACnet conformance class 3 device.

Standard BACnet object types supported shall include as a minimum: Analog Input, Analog Output, Analog Value, Binary Input, Binary Output and Binary Value. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

The Building Controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork. Must support interoperability on wide area networks (WANs) and campus area networks (CANs).

The main network shall utilize either Ethernet or RS485 media and support a minimum of 32 GC/LAN controllers on a full peer to peer communications network. Each GC/LAN shall support at a minimum 2 sub LAN networks capable of communicating with up to 124 Field Panels or Local Controllers per LAN. All sub LAN networks shall be true peer-to-peer networks.

Web-Enabled Global LAN Controller Panel (WGC/LAN/DDC) Direct Digital Controller

Provide a web-enabled, programmable direct digital Global LAN Controller Direct Digital Controller that can be used in a stand-alone environment, networked to other controllers, or as part of a complete facilities management system (multiple LAN). The main network shall utilize Ethernet media and support a minimum of 32 WGC/LAN/DDC controllers on a full peer to peer communications network. Each WGC/LAN/DDC shall support at a minimum 1 sub LAN networks capable of communicating with up to 32 Field Panels or Local Controllers. All sub LAN networks shall be true peer-to-peer networks.

This controller may also be used to optimize the energy consumption by implementing various Energy Management strategies such as; demand

limiting, duty cycling, outside air optimization, temperature setup/setback optimum start/stop routines, etc.

Dedicated serial port shall be provided for simultaneous direct connected operator station or an auto dial/auto answer modem. Other on board features shall include:

Internet Accessible with standard WEB browser. No other software required.

Stand-alone or networked peer-to-peer capabilities

2-Way modem communications capability

Power-fail with auto restart capabilities
Programs and program parameters are stored in nonvolatile flash memory.

Local Controller (LC)

The LC is a line of full peer-to-peer, programmable direct digital controller. Used in a stand-alone environment, networked to other Local controllers, or as part of a complete facilities management system (multiple LAN), the Local controllers provide precise monitoring and control of connected points. Through basic programming it is easy to implement proportional (P), proportional + integral (PI), or proportional + integral + derivative (PID) control sequences. These controllers may also be used to optimize the energy consumption by implementing various Energy Management strategies such as; demand limiting, duty cycling, outside air optimization, temperature setup/setback, optimum start/stop routines, etc.

On-board features include:

Stand-alone or networked peer-to-peer capabilities,

2-Way modem communications

8 Universal Inputs with 10 bit resolution- software selectable as analog or digital with standard and custom ranges. Pulse counting shall be available for all inputs up to 16Hz frequency

8 Universal Outputs with 10 bit resolution - software selectable for analog or digital with standard and custom ranges. Optional output cards all with Hand-Off-Auto switches and switch feedback for the following outputs:

Alarm buffering up to 10 alarms

8 Standard P, PI, or PID controllers each with the following adjustable parameters:

8 Trend Logs for data logging purposes, each supporting up to 4 analog, digital or virtual elements or points; when linked to the operating system these logs may be graphically displayed

8 Runtime Logs with time/date stamp and cumulative runtime

4 Weekly Time schedules with overrides

2 Annual Routines for Holiday Schedules

3 Sensor conversion tables for creating linear curves

6 Access Levels with 27 individual user passwords
On-board 68 character full English alarm messages

Terminal Unit Controllers (TUC)

Terminal Unit Controllers shall utilize a high speed RISC processor that will read all inputs, execute all programs and write to all its outputs at least ten (10) times per second. The inputs and the outputs shall be defined in software as an analog input, digital input, analog output, or digital output. The controller shall be able to survive the application of 24 VAC to any input channel and/or the RS-485 communications trunk. The enclosure shall have a UL 94 5V rating or equivalent.

Terminal Unit controllers shall communicate at minimum on a master/slave communication protocol with a minimum of 96 other local controllers and/or terminal unit controllers on the Terminal Unit Controller LAN with the aid of a higher level processor (MBC, NAE, BCM).

Application Specific Terminal Unit Controllers shall be available in the following configurations:

Air Handling Unit Controller

Terminal Box Controllers(VAV's)

Microprocessor Based Space Sensor

A microprocessor based space sensor residing on a RS-485 network shall provide the following functions:

Space temperature measurement and indication

Outside air temperature indication

Space temperature setpoint adjustment

View the value of any input or output in the system

Change the value of any input, output or software point in the system

The above functions shall be field programmable if desired

Space temperature sensor shall be capable of ± 2°F local adjustment.

All Terminal unit controllers shall be capable of interface to this microprocessor based room sensor.

In addition to the space temperature input, a Digital Input shall also be available at the sensor in addition to all other inputs at the associated controller.

The microprocessor based room sensor shall include an RJ11 jack for connection of a PC to the entire LAN network. Microprocessor based sensors whose RJ11 jack only allows communication with the controller to which it is connected shall not be acceptable.

Auxiliary Control Devices

Automatic Control Dampers And Operators

1. See control damper section requirements herein (sheet 13).

2. Damper operators shall be spring return or capacitor charged return, unless indicated otherwise on plans.

3. Damper frames shall not be less than 13 gauge-galvanized steel, formed for extra strength, with mounting holes for enclosed duct mounting.

4. All damper blades shall be of not less than 16 gauge-galvanized steel formed for strength and high velocity performance. Blades on all dampers must not be over 8" in width. Blades shall be secured to 1/2" diameter zinc plated axles by zinc plated bolts and nuts. Blade side edges shall be sealed off against spring stainless steel seals. Teflon coated thrust bearings shall be provided at each end of every blade to minimize torque requirements and insure smooth operation. All blade linkage hardware shall be constructed of corrosion resistant, zinc plated steel and brass.

B. Differential Pressure Switches

1. Differential pressure switches shall be furnished as indicated by the sequence for status purposes for either air or water applications. Provide single pole double throw switch with fully adjustable differential pressure settings. The switch shall have a snap-acting Form C contact rated for the application. The switch contact shall be rated for 5 amps at 120 volts as a minimum. Units shall be selected for ranges consistent with the application.

C. Electronic Temperature Sensors

1. Temperature sensors shall be thermistors or 100 Ohm platinum RTD. Sensors shall be calibrated to less than or equal to a 1/4 degree F

resolution for the specific application. Substitutions must be approved by FMD Operations and Maintenance. All sensors to be field verified as correct.

2. Provide twisted pair lead wires and shield for input circuit or as otherwise required by the manufacturer.

3. Use insertion elements in ducts not affected by temperature stratification or smaller than one square meter. Use averaging elements where larger or prone to stratification. Sensor length 2.5 m or 5 m as required.

4. Insertion elements for liquids shall be brass separable sockets (thermowells) with insertion length to place end of probe near the center of the pipe.

5. Provide outside air sensors with watertight inlet fittings, shielded from direct rays of the sun. Mount in permanent shade away from building heat radiation or fan exhaust preferably on the North side of the facility.

6. Wall mounted sensor shall be mounted at 48" above finished floor in an area which free air current is not constricted or blocked, final location shall be approved by the Owner and Engineer prior to installation. Wall sensors in corridors shall have a locking guard.

7. Sensor elements shall be applicable for the medium being sensed; i.e., room elements, well-mounted elements, duct mounted elements and outdoor mounted elements. Range shall be from 0 to 150 degrees F.

D. Electronic Static Pressure Sensors

1. Static pressure sensors shall be differential pressure sensors, with the "high" output sensing the duct pressure and the "low" input sensing atmospheric pressure.

2. The range for the static pressure sensor shall be matched to the static pressure of the system being sensed, 0 to .1 inches, 0 to .25 inched, 0 to .5 inches, 0 to 2 inches, 0 to 5 inches, or 0 to 10 inches.

3. Accuracy shall be plus or minus 2% of the full range being sensed.

E. Temperature Thermostats (Stand/Alone Applications, As Required)

1. Digital thermostats shall be provided.

F. Humidity Sensor/Transmitter

1. Provide relative humidity sensor/transmitter where shown on the control drawings. Sensor and transmitter shall have:

System Accuracy: 2% RH @ 25°C from 20-95% RH

Output Signal: Two wire 4-20 ma linear, proportional to 5-95% RH

2. The transmitter power shall be compatible with and powered by, the low voltage power supplied by this Contractor.

G. Carbon Dioxide Gas Sensor/Transmitter

1. Sensor/transmitter shall meet the following specifications:

Measurement Range:	0 to 5,000 PPM (software adjustable to 9,999 PPM)
Accuracy:	±5% of reading or 100 PPM, whichever is greater
Response Time:	Less than one (1) minute
Output Signal:	4-20 ma linear
Output Impedance:	1000 Ohms
Repeatability:	20 PPM
Drift:	l0 PPM per year
Calibration Adjustments:	Offset and span (software adjustable)
Sensor Operating Principal:	Absorption infrared (non-disperse)

Minimum Required Characteristics

Calibration Interval:	One (1) year
Operating Temp. Range	32°F to 122°F
Operating Humidity Range:	5-95% RH non-condensing
Power Requirement:	16-24 VAC, 60 Hz, 16-30 VDC
Current Requirement:	500 ma peak
Operating Elec. Environment:	Floating or Grounded
Dimension (HxWxD):	4" x 7.5" x 3"
Unit Enclosure Material:	UL Fire Rated
Manufacturer:	Telaire International Corp. or pre-approved substitute
Operator Display:	LCD readout required in duct units; no display required for room mounted units.
Calibration Requirements:	Software, 2 gas canisters (or 2 gas canisters for every 3 units installed, whichever is greater), and interface cabling for RS-232
Ancillary Devices	Provide mounting bases and/or aspiration box as required per manufacturers recommendation
Warranty	Two (2) year parts, shipping, and labor required. Contractor to keep sufficient spares locally available so as to minimize downtime due to delays in shipping
Acceptable manufacturers -	Telaire Vendostat 2001V Innovair CD100VC

ELECTRICAL WIRING

All cable runs exposed in return air plenums shall be smoke rated for the application and secured to the building structure. Do not run wire in drywall without conduit.

All cables above hard ceilings shall be run in EMT conduit with compression fittings.

All Ethernet LAN cable shall be run in EMT conduit in all locations

All DDC J-boxes shall be painted blue to identify DDC wiring

All wiring cables shall have 600-volt insulation.

Cables shall be properly identified/tagged with matching wire markers on both ends as to the control point. Wire tags to be wrap around or sleeve type and shall identify each I/O point on each controller.

Each panel controller shall have a I/O wire tag list attached to the panel inside cover.

All cables from ceilings to wall temperature sensors shall be installed in conduit (EMT). EMT Conduit fittings shall be steel compression type. Set Screw fittings are not acceptable.

ACCEPTANCE PROCEDURE

Upon completion the BAS contractor shall calibrate all sensors and control devices for correct operation. Control contractor shall provide written record of all calibrations showing offset amount and all offsets programmed into the system.

Control contractor shall perform a complete Point to Point test and calibration of all control components. The contractor shall perform all commissioning prefunctional and functional testing as described in the commissioning specifications and the commissioning plan. The control contractor shall be a key part of the commissioning team and shall cooperate with all commissioning activities and meetings.

Control contractor shall include in scope adjustment of alarm settings and time delays to remove any nuisance and false alarms.

TRAINING

The BMS Contractor shall conduct a training class for designated Owner’s personnel in maintenance and operation of control system.

Course shall include instruction on specific systems and instructions for operating installed system to include as a minimum:

HVAC system overview.

Operation of control system and HVAC available data and sequences

Plumbing, fuel, gen set, fire alarm interfaces, available data, and sequences

Function of each component.

System operating procedures.

Programming procedures.

Maintenance procedures.

Selection of all displays and reports.

Password assignment and modification.

Walk-through of the job to locate control components.

Operation of portable operations terminal.

Explanation of adjustment, calibration and replacement procedures.

Provide costs for one week factory software programming training for one MCC control service technician. Include cost of tuition, training materials and all travel and living expense for the training period.

SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning with Substantial Completion, provide software support for two years including (6) trips to site on approximately 4 month intervals or as required by the Owner to perform any required or desired algorithm adjustments, sequence of operation changes/adjustments, set point adjustments, and explain/train operators on use of the control system. Each visit shall be logged and all adjustments recorded by attendees. The goal shall be to improve the control system performance continuously over two years and eight seasons so that the control system operates as well as can be achieved.

C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two year from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

CONTROL VALVES

Modulating Control Valves ½" – 1"

Shall be brass body ball valves with stainless steel trim and stem with anti-blow out stem with dual Viton o-rings. Seat shall be PTFE and the ball shall have a characterized insert made from glass-filled PEEK. Valve service shall be capable of hot water and chilled water up to 60% glycol with body static pressure of 600 psi and a fluid temperature of 20° to 250°. Seat leakage shall be ANSI class IV (0.01%) with a rangeability of 300:1. Actuator shall be 24VAC modulating non spring return actuator. Valve shall be Snyder Electric VBB2N two way or VBB3N three way as indicated on the drawing or equal valves from Johnson Controls or Siemens Controls.

Modulating Control Valves 1 ¼" – 2"

Shall be brass body globe valves with stainless steel trim and stem with TFE packing. Seat shall be stainless steel and the valve shall be modified for equal percentage flow characteristics Valve service shall be capable of hot water and chilled water with body static pressure of 250 psi. Valve shall have a rangeablility of 75:1. Actuator shall be 24VAC modulating non spring return actuator. Valve shall be Snyder Electric VB-7213 two way or VB 7313 three way as indicated on the drawing or equal valves from Johnson Controls or Siemens Controls.

Modulating Control Valves 2 1/2" – 6"

Shall be iron body globe valves with stainless steel trim and stem with TFE packing and brass seat. Valve service shall be capable of hot water and chilled water with body static pressure of 125 psi. Valve shall have a rangeablility of 75:1. Actuator shall be 24VAC modulating non spring return actuator. Valve shall be Snyder Electric VB-9213 two way or VB-9313 three way as indicated on the drawing or equal valves from Johnson Controls or Siemens Controls.

Isolation Valves 2 1/2" – 6"

Shall be iron lug body butterfly valves with bubble tight shut off EPDM seats and stainless steel stem. Valve shall have a ductile iron disc coated with Nylon 11. Valve service shall be capable of hot water and chilled water with body static pressure of 125 psi. Actuator shall be 120VAC two position non spring return actuator. Valve shall be Snyder Electric or equal valves from Johnson Controls or Siemens Controls.

Diverting Control Valves 2"

Shall be nickel plated brass, with full port chrome plated brass ball, nickel plated brass stem, with EPDM Seal and PTFE valve seat, and shall be equal to Belimo B350L. Valve service shall be capable of hot water and chilled water with minimum body static pressure of 400 psi. Valve shall have a rangeablility of 75:1. Actuator shall be 120VAC two position spring return actuator. Diverter valves shall be positive shut-off for diverter applications. Note 2" diameter diverter valves are acceptable for 2.5" piping provided that reducers are provided directly upstream/downstream from the valve at all connections. Actuators shall have have an open close indicator and shall alarm upon a valve status mismatch, see sequence of operations.

Diverting Control Valves 2 1/2" – 6"

Shall be iron body two seat globe valves with stainless steel trim and stem with TFE/EPDM packing and brass seat. Valve service shall be capable of hot water and chilled water with body static pressure of 125 psi. Valve shall have a rangeablility of 75:1. Actuator shall be 120VAC two position spring return actuator. Valve shall be Snyder Electric VB-8303 three way as indicated on the drawing or equal valves from Johnson Controls or Siemens Controls. Diverter valves shall be positive shut-off for diverter applications. Actuators shall have have an open close indicator and shall alarm upon a valve status mismatch, see sequence of operations.

CONTROL DAMPERS, RECTANGULAR AUTOMATIC

PART 1 GENERAL

1.1 WORK INCLUDED

A. Galvanized steel control dampers which lock together without bolts, screws, or rivets and suitable for application in HVAC systems with velocities to 4000 feet per minute (15.2 m/s)

1.2 RELATED WORK

A. Section 15810 – Ducts.

B. Section 15900 – HVAC Instrumentation and Controls: Connections to actuators.

1.3 REFERENCES

A. AMCA 500-D – Laboratory Methods for Testing Dampers for Ratings.

B. AMCA 511 – Certified Ratings Program for Air Control Devices.

C. IECC - International Energy Conservation Code.

1.4 SUBMITTALS

A. Comply with requirements of Section 233300 – Submittal Procedures.

B. Product Data: Submit manufacturer's product data.
   1. Include leakage, velocity, pressure drop and maximum pressure data
   2. Indicate materials, construction, and dimensions.
   3. Include pressure drop data for all damper sizes in accordance with AMCA 500-D test figures 5.2 (Ducted Inlet, Free Outlet), 5.3 (Ducted Inlet, Ducted Outlet) and 5.5 (Free Inlet, Free Outlet).
   4. Include a copy of Installation Instructions.

1.5 QUALITY ASSURANCE

A. Quality of all devices shall be acceptable to the Engineer, Owner and Operator.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver Materials to site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer, material, and location of installation.

B. Storage: Store materials in a dry area indoor, protected from damage, and in accordance with manufacturer's instructions.

C. Handling: Handle and lift dampers in accordance with manufacturer's instructions. Protect materials and finishes during handling and installation to prevent damage.

PART 2 PRODUCTS

2.1 MANUFACTURER

A. Greenheck, PO Box 410, Schofield, Wisconsin 54476-0410. Phone (715)359-6171. Fax (715)355-6458. Web Site www.greenheck.com. Or Equal.

2.2 HVAC Control Damper

A. Model: VCD-33

B. Ratings

Leakage:

- Dampers shall have a maximum leakage of 6 cfm/ sq. ft. @ 4 in. wg or 3 cfm/ sq. ft. @ 1 in. wg.
- Damper shall meet or exceed the IECC (International Energy Conservation Code) requirements for damper leakage ratings of 3 cfm/ sq. ft @ 1 in. wg or 8 cfm/sq. ft. @ 4in. wg or less when integral to the building envelope.

1. Differential Pressure:
   - Dampers shall have a maximum differential pressure rating of 8 in. wg (2 kPa).

2. Velocity:
   - Dampers shall have a maximum velocity rating of 4000 fpm (20.3 m/s).

C. Construction:

1. Frame:
   Damper frame shall be 16 ga. galvanized steel formed into a 5" x 1" structural hat channel. Top and bottom frame members on dampers less than 17" high shall be low profile design to maximize the free area of these smaller dampers. Frame shall be 4-piece construction with 1 ½" (minimum) integral overlapping gusset reinforcements in each corner to assure square corners and provide maximum resistance to racking.

2. Blades:
   Blades: Damper blades shall be airfoil shape galvanized steel double skin construction (14 ga. equivalent) on VCD-33. Each blade shall be symmetrical relative to its axle pivot point, presenting identical performance characteristics with air flowing in either direction through the damper. Provide symmetrical blades of varying size as required to completely fill the damper opening. Blade

orientation is horizontal. Blade operation is parallel or opposed as indicated on the drawing schedule.

3. Blade Stops:
Each blade stop (at top and bottom of damper frame) shall occupy no more than ½" of the damper opening area to allow for maximum free area and to minimize pressure loss across the damper.

4. Seals: VCD-33
   a. Blade Edge: Blade seals shall be TPE or silicone permanently bonded to the appropriate blade edges. Silicone blade seal is optional.
   b. Jamb: Flexible stainless steel compression type

5. Linkage: Concealed in jamb, plated steel material.

6. Axles: Minimum ½ inch dia. plated steel.

7. Bearings: Axle bearings shall be bronze bearing type in the damper frame.

8. Finish: Mill Galvanized finish is standard. Paint coatings are optional.

2.3 ACCESSORIES

A. Actuators:
   1. Actuators shall be provided and installed by the Mechanical Controls Contractor under the Mechanical Scope of Work. Actuator Mounting shall be external to damper and duct, except at the generator exhaust dampers where they require internal mounting.

B. OCI Switch

Two position indicator switch directly linked to damper blade to remotely indicate damper blade position.

C. Flange Frame
1½ inches, rolled formed as part of frame.

D. Sleeve
Damper sleeve supplied as a single assembly with a factory sleeve.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Factory cycle damper and actuator assemblies to assure proper operation.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas to receive dampers. Notify the Engineer of conditions that would adversely affect installation or subsequent utilization of dampers. Do not proceed with installation until unsatisfactory conditions are corrected.

3.2 INSTALLATION

A. Install dampers in accordance with manufacturer's Installation Instructions.

B. Dampers must be accessible to allow inspection, adjustment, and replacement of components. The sheet metal contractor shall furnish any access doors in ductwork or plenums required to provide this access. The general contractor shall furnish any access doors required in walls, ceilings, or other general building construction.

C. Install dampers square and free from racking.

D. The installing contractor shall provide and install bracing for multiple section assemblies to support assembly weight and to hold against system pressure.

E. Do not compress or stretch the damper frame into the duct or opening.

F. Attach multiple damper section assemblies together in accordance with manufacturer's instructions. Install support mullions as reinforcement between assemblies as required.

G. Handle dampers using the frame or sleeve. Do not lift or move dampers using blades, actuator or jackshaft.

H. Install connections to electric actuators as specified in main controls section.

PART 4 SUBMITTALS

4.1 REQUIRED SUBMITTALS

A. Provide Complete Project Specific Control Drawings, Project Specific Sequence of Operations, and Project Specific Points Lists.
B. Provide Complete BOM
C. Provide all system information, including alarm points and data trends and reports.
D. Product Device Specifications
E. Provide complete set of AS-Builts at project completion.

PART 5 WARRANTEE PERIOD TROUBLE SHOOTING SERVICES

Warrantee Period Trouble Shooting Services: The Controls Contractor shall provide the senior technician who completed the facility controls installation to attend up to six warrantee period trouble shooting meetings on site at the request of the engineer. Such meetings may be arranged to be attended jointly with the engineer, TAB contractor, and/or the mechanical contractor to jointly assist in trouble shooting activities and to assist in the remedy of any building HVAC system operational difficulties. Such meetings may require additional adjustments or modification of settings, sequences of operation, controls programming, and similar refinements to obtain the best possible performance of the HVAC systems. Setting adjustments requested by the owner or others shall not be included in the count of six trouble shooting meetings. For any of the six meetings the controls contractor shall be prepared with tools and equipment necessary to adjust controls systems as directed by the engineer.

END OF SECTION

SECTION 23 21 13

CHILLED WATER, CONDENSER WATER, AND HOT WATER PIPING

PART 1 GENERAL

1.1 SCOPE

A. Chilled and Condenser Water Piping:

1. Use electric resistance welded (ERW) black steel grooved end or welded piping for all chilled water piping. Use grooved end or full pattern welded fittings for pipe 2-1/2" and larger and screwed piping mains with malleable iron fittings for piping 2" and smaller. Type L Hard Drawn Copper Tubing ASTM B88 soldered, or brazed joints for piping 2" and smaller shall be an acceptable alternate.

2. Use grooved joint couplings or flanges on piping 2-1/2" and larger and unions on piping 2" and smaller. Provide service valves at all equipment and at all branch takeoffs and elsewhere as indicated on drawings using ball valves on piping 2" and smaller and lug style butterfly valves on piping 2-1/2" and larger. Provide shutoff valve, flexible connections, and strainer on suction side of pumps; plug valve, non-slam check valves, and flexible connection on discharge side of pumps.

a. Grooved joint flexible couplings may be used in lieu of flexible connectors at equipment connections. Three couplings shall be placed in close proximity to the vibration source.

B. Pressure Testing:

1. All hydronic piping systems shall be pressure tested to 1.5 Times the maximum designed operating pressure for a minimum period of 1-hr with no detectible drop in pressure.

2. Pressure testing shall be observed by engineer prior to acceptance.

PART 2 DESIGN STANDARD

2.1 PIPING

A. Above Grade Piping: ERW black steel, ASTM A-53, Grade B, welded pipe in conformance with the following schedule:

Size (Inches)	Pipe			Fittings		
	Wall Thickness	Sched.	Weight	Wall Thickness	Sched.	Weight
8 & smaller	Varies	40	Standard	--	40	Standard
10	.365	40	Standard	.365	40	Standard
12	.375	--	Standard	.375	--	Standard
14	.375	30	Standard	.375	30	Standard
16	.375	30	Standard	.375	30	Standard
18	.500	--	X-Heavy	.500	--	X-Heavy

BACKFLOW PREVENTERS

B. Reduced Pressure Backflow Preventer: Watts Series 909S for sizes up to 2", Series 909-NRSS for 2-1/2" and larger, or Series 909SHW for hot water, complete assembly including full port, resilient seated, bronze body test cocks and shutoff valves, Celcon check seats, stainless steel relief valve seats, shafts and flange bolts, tight-seating rubber check valve and relief valve assemblies, and inlet strainer with emergency repair kit.

C. Furnish and install air gap drain fitting and pipe to nearest floor sink when installed inside building.

2.2 STRAINERS

A. Strainers shall be wye self-cleaning flush type, gray cast iron, with bronze monel metal or stainless steel sediment strainer and 3/4" gate blow-off valve, piped to floor sink or drain. Strainers shall be separate from other components. Integral strainers and traps will not be approved. Strainers 3" and smaller shall have 1/32" perforations and strainers 4" and larger shall have 1/8" perforations and have a minimum open area of three times the area of strainer inlet pipe. Use 40 mesh screens and Everdur wool packing during initial cleaning of system.

END OF SECTION

SECTION 23 21 15

PIPING SPECIALTIES

PART 1 GENERAL

1.1 WORK INCLUDED HEREIN

A. Provide and install piping specialties as specified herein and as shown on the drawings.

PART 2 DESIGN STANDARD

2.1 AIR VENTS

A. Install automatic air vents where indicated and at all high points of each system. Automatic air vents on piping 3” and above is to be Hoffman Model 79; on piping below 3” is to be B&G Model 87 (Armstrong approved equal). Vents to be threaded 3/4” connection. Manual vents are to be B&G No. 4 “coin operated” air vent (Armstrong approved equal). Install manual air vents on all cooling and heating coils and elsewhere as indicated. Provide a ball valve ahead of all automatic and manual air vents.

2.2 FLEXIBLE CONNECTIONS

A. For connections at pumps, Flex-Hose Pumpsaver Model SMP, or approved equal, minimum of 150 PSI and 850°F, 18” minimum length or longer if needed per pump manufacturer, braided stainless steel pump connectors at final connections to all pumps and elsewhere as shown. End connections shall be carbon sheet plate flanges. Support piping in a manner that will not allow it to rest on or compress the units. The manufacturer's name shall be affixed to each unit.

B. For connections at air handlers and fan coil units, Flex-Hose Model FC-S24 flexible connector, stainless steel outer braid, brass connectors, 24" long, 150 PSI and 212°F. The manufacturer's name shall be affixed to each unit.

2.3 FLEXIBLE LOOPS, ANCHORS AND EXPANSION JOINTS

A. Flexible Loops: Flex-Hose Tri-Flex TFL2SMP or TFL4SMP flexible expansion loops. Construction to be annular corrugated 321 stainless steel close-pitch hose with stainless steel overbraid that will absorb or compensate for pipe movements in all six degrees of freedom simultaneously. The corrugated metal hose, braid(s), and a stainless steel ring-ferrule/band must be integrally seal-welded. End fittings shall be flat-face plate steel flanges. Braided stainless steel must be suitable for operating temperatures up to 850°F and 150 PSI operating pressure. Loop(s) must be designed for pressure testing to 1.5 times their maximum rated working pressure and a minimum 4:1 (burst to working) safety factor. Shipping bar must be removed prior to system startup. Loops shall be covered with a three-year full replacement warranty when installed in accordance with all specifications and installation instructions.

B. Anchors: Where required, and as shown on the drawings, suitable pipe anchors properly braced and supported to the building structure shall be installed under this section.

C. Expansion Joints:

1. Flex-Hose BF/150 controlled flexing expansion joints, stainless steel bellows with control rods and compression stops, minimum of 150 PSI working pressure and 650EF. Minimum 1" compression for piping 2" through 5" and 2" compression for piping 6" through 12". Provide a minimum of two pipe guides on each side of all joints or as recommended by the manufacturer.

2. Expansion joints and pipe guides shall be installed in strict accordance with the manufacturer's recommendations, with full allowance made for contraction of joint when pipeline reaches its minimum cold temperature. Each expansion joint and pipe run shall be anchored as required for proper pipe, pipe guides, and expansion joints, and pipe run shall be anchored as required for proper pipe, pipe guides, and expansion joint supports. All anchors shall be approved before installation.

D. Submit anchors and pipe guides for approval before installation. Guides shall be Flex-Hose Model GDX-P.

E. Anchor all piping as detailed or as required for proper pipe, pipe guide, and expansion joint support.

2.4 PIPELINE TEMPERATURE INDICATION

A. Thermometers:

1. All pipeline thermometers shall be Trerice Series BX-9, or approved, one-piece case industrial thermometer with glass front, baked black enamel case, brass separable socket, red reading thermometer tube, swivel nut on stem (allows installing without rotating thermometer).

2. All thermometers are to have 9" scale and 1°F scale division. Submit temperature ranges for approval.

B. All thermometer wells are to be extension stem type to clear insulation, except condenser water service.

C. Three-quarter-inch Thread-O-Lets shall be welded to pipe, or pipe size to 3/4" threaded tee furnished for mounting of well. Direct welding of wells in pipelines will not be permitted.

D. Pipeline Temperature and Pressure Indicators: Furnish and install Peterson Co. "Pete's Plugs" or Sisco pressure/temperature plugs as shown on drawings (yellow dot for heating systems, blue dot for chilled water systems). Provide the Owner with two sets of pressure/temperature probes for his use.

2.5 PRESSURE GAUGES

A. Furnish and install Marsh "Master," Trerice 500X, Weksler "Regal" or approved pressure gauges where indicated. The gauges shall have 4-1/2" dial size. The case shall be plain or screwed ring depending on whether the gauge is to be mounted on a panel or to be pipe supported. Cases shall be cast aluminum. The scale range shall be 0 to 150 PSI for all water, monel rotary type, nylon gear movement.

B. When gauges are apt to be subjected to a vacuum, provide compound gauges reading 30" to 150 PSI.

C. Install a siphon under gauges used on steam service.

D. Provide a needle valve at each gauge connection to allow periodic gauge complete removal and replacement. Valves shall be Whitey IV-4 or approved.

END OF SECTION

SECTION 23 31 17

SHEET METAL DUCTWORK (MEDIUM PRESSURE)

PART 1 GENERAL

1.1 SUMMARY

A. Use medium pressure duct for all discharge ductwork from air handling or air conditioning units scheduled in excess of 2" external static pressure. This shall be without regard to actual air velocities involved. All material, equipment, construction and testing for all medium velocity ductwork and apparatus casing shall conform to the latest SMACNA Duct Construction Standards Manual.

Pressure Class	*System*	*Seal Class Required*
4" (medium)	*Ducts from AH to each TU inlet*	*A*
2" (medium)	*Ducts from TU to devices, relief, exhaust ducts*	*A*

B. Ductwork Handling and Storage:

1. Ductwork shall arrive on the project site with polyethylene film or other waterproof covering over the open ends which will prevent the entrance of dust, debris and moisture. Ductwork shall be stored in a clean and dry location. Any ductwork which is observed with interior dust and/or debris shall be cleaned and not re-installed until approval is received from the Architect/Engineer. Any ductwork which is observed to have wet interior insulation shall be removed from the jobsite and new ductwork furnished at the Contractor's expense.

2. At ends of ducts which are not connected to equipment or air distribution devices at the time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until the time that connections are to be completed.

C. Fabricate ductwork and fittings according to SMACNA's "HVAC Duct Construction Standards" unless noted otherwise.

PART 2 DESIGN STANDARD

2.1 GALVANIZED SHEET STEEL

A. Galvanized, prime grade, lock forming quality steel having a G60 galvanized coating. All ducts with any dimension greater than 16" shall be flanged type duct construction.

2.2 MANUAL DAMPERS

A. Minimum of 16 gauge galvanized steel, maximum of 8" blade, opposed blade type, with manual quadrant.

2.3 MANUAL QUADRANTS

A. On all medium pressure manual dampers, Young #453G in insulated ducts or inaccessible ducts, #433G in uninsulated ducts, or approved equal. In inaccessible locations (above plaster ceilings, etc.), provide Young #617 damper, 3/8" rod, and extend to Young #325 flush mounted damper regulator, cadmium-plated, suitable for painting, complete with indicator to show position of damper and operating wrench.

2.4 TURNING VANES

A. Sheet Metal Vanes: Provide large radius, double thickness turning vanes in all 90 degree square elbows. Shop fabricated duct turns shall be submitted for approval prior to progressing any work on project.

2.5 ACCESS PANELS AND DOORS

A. Uninsulated Ductwork: Install with 1" x 1" x 1/8" thick reinforced angle frames and make airtight with felt strips of neoprene gasketing. Latches to be Ventlock #333 as manufactured by Ventfabrics, Inc., or approved equal.

B. Access Panels and Access Openings in Ducts: Galvanized sheet steel two gauges heavier than the duct and provided with a rolled steel metal edge, sealed airtight to the duct with felt strips or neoprene gasketing and attached to duct with sheet metal screws a maximum of 6" on center.

C. Insulated Ductwork: Double thickness galvanized sheet metal of same gauge as duct (minimum 20 gauge), with a minimum of 1-1/2" thick fiberglass, 3-pound density insulation between sheet metal, rolled edges, hinges, and Ventfabrics, Inc. Ventlock #333 latches.

D. See drawings and verify with architectural drawings for location of smoke partitions. Provide combination fire and smoke dampers in all smoke partitions.

2.6 DUCT SUPPORTS

A. Support all ducts from hanger straps or hanger rods as specified herein or in the SMACNA Manual. Ducts with a maximum dimension of 60" shall be supported on not lighter than 1" wide, 22 gauge galvanized steel strap or 3/8" diameter steel rods, a maximum of 8 feet on center. Support ducts 61" to 120" with 2" x 2" x 1/4" thick galvanized steel angle trapeze and 3/8" diameter steel rods. Support ducts 121" to 240" maximum dimension with 2-1/2" x 2-1/2" x 3/16" thick galvanized steel angles and 3/8" diameter steel rods supports. See additional details on the drawings.

2.7 DUCT CONSTRUCTION (ROUND AND OVAL DUCT)

A. General: Use galvanized sheet metal as hereinbefore described for all round and oval ductwork, complete with all fittings, reinforcing, bracing, etc., as required and specified herein. See drawings for sizes and locations of ductwork.

B. Fabrication: Carefully plan and coordinate with other trades to assure straight,

unbroken runs of ducts with a minimum of offsets and transitions. Do not fabricate and erect ductwork that varies substantially from that indicated without prior written approval.

C. Joints: All joints and seams in fabricated ducts and fittings must be carefully cut and trimmed to form a tight joint. No portion of the duct or fittings shall protrude into the airstream. All factory fabricated fittings and joints must be brazed with Everdur rod. Field fabricated transverse joints may be brazed with Everdur rod or make up with a slip joint using sheet metal screws and duct sealing compound. Duct made up with duct sealer shall have a minimum of 2" overlap and be sealed with duct sealing compound (as hereinbefore described), applied to both parts for the full length of the overlap. Secure joints with drive screws spaced not more than 6" on center around the ducts using a minimum of three screws. Tape all joints with three overlap layers of approved industrial tape, each applied over a fresh layer of duct adhesive.

D. Gauges: Sheet metal gauges for round ductwork, girth reinforcing, girth joints, etc., shall be as described in the SMACNA Manual.

2.8 DUCT CONSTRUCTION (SQUARE AND RECTANGULAR DUCT)

A. General: Construct all rectangular ducts of galvanized sheet steel (as hereinbefore described). All sides of ducts shall be cross-broken and reinforced as hereinafter described. Ducts shall be complete with all fittings, reinforcing, bracing, etc., as specified herein and required for proper assembly.

B. All ductwork joints, seams, and duct penetrations shall be sealed to reduce leakage and improve efficiency using mastic sealing compound.

C. Longitudinal Seams: Pittsburgh lock, hammered flat and welded or made up with sealing compound as follows:

1. Longitudinal seams may be made up with duct sealing compound (as hereinbefore described) applied to a Pittsburgh lock and hammered flat. In addition, coat the inside seam with the duct sealing compound in combination with a polyvinyl coated, open weave fiberglass tape, 2" wide. Submit details for fabrication before progressing with any work.

D. Transverse joints may be welded flange joints, gasketed flanged connections, or other joints as recommended in Section 2 of the SMACNA Manual, with suitable reinforcement at the joint and between joints as required.

E. Joints in factory-made ducts and fittings may be brazed with an Everdur rod or may be made as follows:

1. All joints shall have a minimum overlap of 2" and shall be sealed with adhesive, applied to both parts for the full length of the overlap. The joints shall be secured with drive screws spaced not over 6" apart, around the duet, with not less than three screws. Joints shall then be taped with three layers of approved industrial tape applied over a fresh layer of the adhesive.

2. At the option of the Contractor, the sealing of duct joint and fitting connections of medium velocity air conditioning duct systems where round and/or flat oval duct and fitting connections are used may be sealed by using the Thermofit air conditioning duct sealing band (TCB) as manufactured by Rayclad Tubes, Inc. The duct band shall be made in a one-piece unit for each duct diameter and supplied in its expanded form. It shall be internally coated with a heat-activated adhesive. When exposed to heat in excess of 250EF the duct band shall shrink and the adhesive melt. Pressure of the shrinking band shall force the molten adhesive into the void areas of the connection. As the duct band cools, it shall provide permanent mechanical strength and positive seal against loss of internal pressure and of external ingress of moisture.

F. All sides of ducts shall be cross-broken and shall be brazed with girth angles brazed to duct at not over 24" on center.

G. Elbows: Square elbows shall be used only where shown and shall have double radius acoustical turning vanes installed in strict conformance with manufacturer's recommendations.

2.9 FLEXIBLE DUCT

A. Nonmetallic reinforced flexible tubing may be used for medium velocity ductwork where required. The use of flexible duct shall be limited to minor offsets and to final connections to the attenuator boxes. The length of flexible duct shall be as short as possible, but no bends shall have a throat radius less than 1-1/2 times the radius of the duct. Flexible duct length shall not exceed six (8) feet. The major portion of the branch takeoffs to the attenuator boxes shall be made with rigid duct and fittings and the total "bend" of the flexible portion shall not exceed 90 degrees. Flexible duct shall be as hereinbefore specified.

END OF SECTION

SECTION 23 33 13

COMBINATION FIRE/SMOKE DAMPERS & DYNAMIC FIRE DAMPERS

PART 1 GENERAL

1.1 SUMMARY

A. Furnish and install combination fire/smoke dampers where required by code.

B. Combination fire/smoke dampers shall have AIRFOIL blades meeting the requirements of UL Standards 555 (6th Edition).

PART 2 DESIGN STANDARD

2.1 COMBINATION FIRE/SMOKE DAMPERS

A. Model: Greenheck FSD-312 Series combination fire/smoke dampers.

B. Ratings:

1. Fire Resistance:

a. Dampers shall have a UL 555 fire resistance rating of 1-1/2 hours.
b. Dampers shall have a leakage rating of Class I or II.
c. Dampers shall be rated to a minimum airflow velocity of 4,000 FPM.

C. Actuators:

1. Type:

a. Electric, 120V AC, two-position, fail close.
b. Provide with RL/OCI option / end switch for connection to and monitoring by the Building Automation System (BAS).

2. Mounting: External or internal if required.

3. All shall have external reset and test switches.

D. Source Quality Control:

1. Factory Tests: Factory cycle damper and actuator assemblies to assure proper operation.

END OF SECTION

SECTION 23 34 16

EXHAUST AIR

PART 1 GENERAL

1.1 GENERAL BUILDING EXHAUSTS

A. Roof mounted fans are to be factory curb mounted.

B. All belt-drive exhaust fans shall have adjustable motor pulleys for fan speed control.

C. All fans (except toilet exhaust fans 150 CFM and below) must be AMCA certified and approved.

D. Motors on all fans installed on roof or exposed to exterior must have Class B insulation. Motors scheduled for VFD service shall have class F or higher insulation.

E. Provide a factory installed disconnect switch for all 120 volt, single phase fans.

F. Provide multi-speed switches for all multi-speed fan motors.

PART 2 DESIGN STANDARD

2.1 ROOF EXHAUST FANS

A. All exhaust fans less than 1 HP shall be direct drive. All belt-drive exhaust fans shall have spring loaded idler pulleys. All pulleys (except idler) must be steel – no aluminum or pot metal. The fan wheel shall be centrifugal backward inclined, constructed of aluminum, and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced. The fan housing shall be constructed of heavy gauge aluminum with a rigid internal support structure. The fan shroud shall have a rolled bead for added strength.

B. Motors shall be heavy duty ball bearing type, carefully matched to the fan load, and furnished at the specified voltage, phase and enclosure. Motors and drives shall be mounted on vibration isolators. Fresh air for motor cooling shall be drawn into the motor compartment from an area free of discharge contaminants. Motors shall be readily accessible for maintenance.

C. A disconnect switch shall be factory installed and wired from the fan motor to a junction box installed within the motor compartment.

D. A fan conduit chase shall be provided through the curb cap to the motor compartment for ease of installation.

E. Required Accessories:

1. Provide pre-fabricated roof curbs to ensure compatibility between the fan, the curb, and the roof opening. All curbs to be insulated with fiberglass and provided with a rubber seal between fan and curb to assure proper sealing when attached to a curb. Curbs are to be sloped to match the roof to allow the fan to set level.

2. Provide backdraft dampers to prevent outside air from entering back into the building when fan is off.

3. Provide hinge kit mounted to the curb cap to allow entire fan to tilt away from curb for access to wheel and ductwork. Include restraint cables.

2.2 IN-LINE FANS

A. In-line exhaust fans shall be of the centrifugal belt-driven in-line or direct drive as specified on the plans. The fan housing shall be constructed of heavy gauge galvanized steel, and shall include square duct mounting collars.

B. Fan construction shall include two removable access panels located perpendicular to the motor mounting panel. The access panels must be of sufficient size to permit easy access to all interior components.

C. Motors shall be heavy duty ball bearing type, carefully matched to the fan load and furnished at the specified voltage, phase and enclosure. Motors and drives shall be mounted out of the air stream. Motors shall be readily accessible for maintenance.

D. Drives shall be sized for a minimum of 150% of driven horsepower.

E. Motor pulleys shall be adjustable for final system balancing. A NEMA 1 disconnect switch shall be provided and wired to motor.

END OF SECTION

SECTION 23 73 13

CENTRAL STATION AIR HANDLERS

PART 1 GENERAL

1.01 WORK INCLUDED

A. Applied Air Handling Units.

1.02 RELATED SECTIONS

A. Section 15900 - Building Automation and Control Systems

B. Section 15950 - Controls and Instrumentation.

C. Section 16180 - Equipment Wiring Systems: Electrical supply to units.

D. Section 01513 - Temporary Heating, Cooling, and Ventilating.

E. Section 15121 - Expansion Compensation.

F. Section 15290 - Duct Work Insulation.

1.03 REFERENCES

A. AMCA Publication 99 – Standards Handbook.

B. AMCA Publication 611 – Certified Ratings Program – Airflow Measurement Performance

C. AMCA Standard 500-D – Laboratory Methods of Testing Dampers for Rating.

D. ANSI/ABMA Standard 9 - Load Ratings and Fatigue Life for Ball Bearings.

E. ANSI/AMCA Standard 204 – Balance Quality and Vibration Levels for Fans.

F. ANSI/AMCA Standard 610 – Laboratory Methods of Testing Airflow Measuring Stations for Rating.

G. ANSI/AHRI Standard 410 - Forced Circulation Air-Cooling and Air-Heating Coils.

H. ANSI/AHRI Standard 430 - Central Station Air Handling Units.

I. ANSI/AHRI Standard 1060 – Rating Air-To-Air Energy Recovery Ventilation Equipment

J. ANSI/ASHRAE Standard 52.2 – Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.

K. ANSI/ASHARE Standard 62.1 – Ventilation for Acceptable Indoor Air Quality.

L. ANSI/ASHARE Standard 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings.

M. ANSI/NEMA MG 1 – Motors and Generators.

N. ANSI/UL 900 – Standard for Safety Air Filter Units.

O. AHRI Standard 260 – Sound rating of Ducted Air Moving and Conditioning Equipment.

P. ASHRAE Standard 84 - Method of Testing Air-to-Air Heat Exchangers.

Q. ASHRAE Standard 111 – Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems.

R. ASTM C1071 – Thermal and Acoustic Insulation (Mineral Fiber, Duct Lining Material).

S. ASTM C1338 – Standard Test Method for Determining Fungi Resistance of Insulation Material and Facings.

T. ASTM E477 – Standard Test Method for Measure Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.

U. NFPA 70 – National Electrical Code®.

V. NFPA 90A – Standard for the Installation of Air Conditioning and Ventilation Systems.

W. UL 1995 – Standard for Safety Heating and Cooling Equipment

1.04 QUALITY ASSURANCE

A. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with current AHRI Standard 410.

B. Air handling units with fan sections utilizing single fans shall be rated and certified in accordance with AHRI Standard 430.

C. Air handling units with fan sections utilizing multiple fans shall be rated in accordance with AHRI Standard 430 for airflow, static pressure, and fan speed performance.

D. Airflow monitoring station: Certify airflow measurement station performance in accordance with AMCA 611.

E. ISO 9001 Certification.

1.05 SUBMITTALS

A. No equipment shall be fabricated or delivered until the receipt of approved shop drawings from the Owner or Owner's approved representative.

B. AHU manufacturer shall provide the following information with each shop drawing/product data submission:

1. Dimensioned arrangement drawings for each AHU including a plan and elevation view of the assembled unit with overall dimensions, lift points, unit shipping split locations and dimensions, installation and operating weights, and installation, operation and service clearances.

2. All electrical, piping, and ductwork requirements, including sizes, connection locations, and connection method recommendations.

3. Each component of the unit shall be identified and mechanical specifications shall be provided for unit and accessories describing construction, components, and options.

4. All performance data, including capacities and airside and waterside pressure drops, for components.

5. Fan curves shall be provided for fans with the design operating points indicated. Data shall be corrected to actual operating conditions, temperatures, and altitudes.

6. For units with multiple fans, a fan curve shall be provided showing the performance of the entire bank of fans at design conditions. In addition, a fan curve shall be provided showing the performance of each individual fan in the bank of fans at design conditions. Finally, a fan curve shall be provide showing the performance of the bank of fans when one fan is down. The percent redundancy of the bank of fans with one fan down shall be noted on the fan curve or in the tabulated fan data.

7. A filter schedule must be provided for each air handling unit supplied by the air handling unit manufacturer. Schedule shall detail unit tag, unit size, corresponding filter section location within the AHU, filter arrangement (e.g. angled/flat), filter depth, filter type (e.g. pleated media), MERV rating, and filter quantity and size.

8. A schedule detailing necessary trap height shall be provided for each air handling unit. Schedule shall detail unit tag, unit size, appropriate trap schematic with recommended trap dimensions, and unit supplied base rail height. Contractor shall be responsible for additional trap height required for trapping and insulation beyond the unit supplied base rail height by adequate housekeeping pad.

9. A coil valve coordination schedule shall be provided for each air handling unit supplied by the air handling unit manufacturer. Schedule shall detail unit tag, coil type and corresponding section location within the AHU, valve style (e.g. global, ball), valve type (e.g. electronic 2-way/3-way), valve position (e.g. normally open/closed), size, flow coefficient (CV), and close-off pressure.

10. An electrical MCA – MOP schedule shall be provided for each electrical circuit to which field-power must be supplied. Schedule to detail unit tag, circuit description, voltage/phase/hertz, Minimum Circuit Ampacity (MCA), and calculated Maximum Overcurrent Protection (MOP).

11. Sound data shall be provided using AHRI 260 test methods. Unit discharge, inlet, and radiated sound power levels in dB shall be provided for 63, 125, 250, 500, 1000, 2000, 4000, and 8000 Hz.

C. The AHU manufacturer shall provide appropriate sets of submittals as referenced in the General Conditions and shall submit to the Owner electronic copies of the IOM.

D. The AHU manufacturer shall list any exceptions to the specification.

1.06 REGULATORY REQUIREMENTS

A. Agency Listings/Certifications

1. Unit shall be manufactured to conform to UL 1995 and shall be listed by either UL/CUL or ETL. Units shall be provided with listing agency label affixed to the unit. In the event the unit is not UL/CUL or ETL approved, the contractor shall, at his/her expense, provide for a field inspection by a UL/CUL or ETL representative to verify conformance. If necessary, contractor shall perform modifications to the unit to comply with UL/CUL or ETL as directed by the representative, at no additional expense to the owner.

2. Certify air handling units in accordance with AHRI Standard 430. Units shall be provided with certification label affixed to the unit. If air handling units are not certified in accordance with AHRI Standard 430, contractor shall be responsible for expenses associated with testing of units after installation to verify performance of fan(s). Any costs incurred to adjust

fans to meet scheduled capacities shall be the sole responsibility of the contractor.

3. Certify air handling coils in accordance with AHRI Standard 410. Units shall be provided with certification label affixed to the unit. If air handling coils are not certified in accordance with AHRI Standard 410, contractor shall be responsible for expenses associated with testing of coils after installation to verify performance of coil(s). Any costs incurred to adjust coils to meet scheduled capacities shall be the sole responsibility of the contractor.

4. Certify airflow monitoring stations are tested for differential pressure in accordance with AMCA 611 in an AMCA registered laboratory and comply with the requirements of the AMCA Certified Ratings Program. Airflow monitoring station shall be licensed to bear the AMCA Seal.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Units shall ship fully assembled up to practical shipping and rigging limitations. Units not shipped fully assembled shall have tags and airflow arrows on each section to indicate location and orientation in direction of airflow. Shipping splits shall be clearly defined on submittal drawings. Cost associated with non-conformance to shop drawings shall be the responsibility of the manufacturer. Each section shall have lifting lugs for field rigging and final placement of AHU sections. Indoor AHUs less than 100 inches wide shall allow for forklift transport for maneuverability on jobsite.

C. Deliver units to jobsite with fan motor(s), sheave(s), and belt(s) completely assembled and mounted in units.

D. Indoor air handling units shall be shipped in a clear shrink-wrap or stretch-wrap to protect unit from in-transit rain and debris per ASHRAE 62.1 recommendations. See Section 2.26 for outdoor air handling unit requirements.

E. Installing contractor shall be responsible for storing AHU in a clean, dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.08 START-UP AND OPERATING REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters in place, bearings lubricated (if applicable), condensate properly trapped, piping connections verified and leak-tested, belts aligned and tensioned, all shipping braces removed, bearing set screws torqued, and fan has been test run under observation.

1.09 WARRANTY

A. AHU manufacturer shall provide, at no additional cost, a standard parts warranty that covers a period of one year from unit start-up or 18 months from shipment, whichever occurs first. This warrants that all products are free from defects in material and workmanship and shall meet the capacities and ratings set forth in the equipment manufacturer's catalog and bulletins.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Approved manufacturer shall be Trane, with pre-approved alternates considered. Manufacturers not pre-approved, must obtain pre-approval in writing from consulting engineer prior to bid day. Alternates must comply with all performance and features as called for in this specification. Job awarded on basis of specified equipment. Alternate will be evaluated and considered after job is awarded.

B. Manufacturer must clearly define any exceptions made to Plans and Specifications. Any deviations in layout or arrangement shall be submitted to consulting engineer prior to bid date. Acceptance of deviation(s) from specifications shall be in the form of written approval from the consulting engineer. Mechanical Contractor is responsible for expenses that occur due to exceptions made.

C. Approved Manufacturers:

1. Trane: Performance Climate Changer

2. Carrier

2.02 GENERAL

A. Unit layout and configuration shall be as defined in project plans and schedule.

B. Unit manufacturer to provide an integral base frame to support all sections of unit and raise unit for proper trapping. Contractor will be responsible for providing a housekeeping pad when indoor air handling unit base frame is not of sufficient height to properly trap unit. Unit base frames not constructed of galvanized steel shall be chemically cleaned and coated with both a rust-inhibiting primer and finished coat of rust-inhibiting enamel.

C. Entire indoor air handling unit shall have a full perimeter base rail for structural rigidity and condensate trapping. See Section 2.26 for outdoor air handling unit requirements.

2.02 UNIT CASING

A. Unit manufacturer shall ship separate segments so unit can be broken down for ease of installation in tight spaces. The entire air handler shall be constructed of galvanized steel. Indoor air handling unit casing finish to meet ASTM B117 250-hour salt-spray test. See Section 2.26 for outdoor air handling unit requirements. The removal of access panels or access doors shall not affect the structural integrity of the unit. All removable panels shall be gasketed. All doors shall have gasketing around full perimeter to prevent air leakage. Contractor shall be responsible to provide connection flanges and all other framework that is needed to properly support the unit.

B. Casing performance – Casing air leakage shall not exceed leak class 6 (C_L = 6) per ASHRAE 111 at specified casing pressure, where maximum casing leakage (cfm/100 ft^2 of casing surface area) = C_L X $P^{0.65}$.

C. Air leakage shall be determined at 1.50 times maximum casing static pressure up to 8 inches w.g. Specified air leakage shall be accomplished without the use of caulk. Total estimated air leakage shall be reported for each unit in CFM, as a percentage of supply air, and as an ASHRAE 111 Leakage Class.

C. Under 55°F supply air temperature and design conditions on the exterior of the unit of 81°F dry bulb and 73°F wet bulb, condensation shall not form on the casing exterior. The AHU manufacturer shall provide tested casing thermal performance for the scheduled supply air temperature plotted on a psychrometric chart. The design condition on the exterior of the unit shall also be plotted on the chart. If tested casing thermal data is not available, AHU manufacturer shall provide, in writing to the Engineer and Owner, a guarantee against condensation forming on the unit exterior at the stated design conditions above. The guarantee shall note that the AHU manufacturer will cover all expenses associated with modifying units in the field should external

condensate form on them. In lieu of AHU manufacturer providing a written guarantee, the installing contractor must provide additional external insulation on AHU to prevent condensation.

D. Unit casing (wall/floor/pressure bulkhead roof panels and doors) shall be able to withstand up to 1.5 times design static pressure up to +8" w.g. in all positive pressure sections and -8" w.g. in all negative pressure sections, whichever is less, and shall not exceed 0.0042" per inch of panel span (L/240).

E. Floor panels shall be double-wall construction and designed to support a 300-lb load during maintenance activities and shall deflect no more than 0.0042" per inch of panel span.

F. Unit casing panels shall be 2" double-wall construction, with solid galvanized exterior and solid galvanized interior, to facilitate cleaning of unit interior.

G. Unit casing panels (pressure bulkhead roof panels, walls, floor) and doors shall be provided with a minimum thermal resistance (R-value) of 13 $Hr*Ft^2*°F/BTU$.

H. Unit casing panels (pressure bulkhead roof panels, walls, floor) and external structural frame members shall be completely insulated filling the entire panel cavity in all directions so that no voids exist. Panel insulation shall comply with NFPA 90A.

I. Structural frame must not extend from air-handling unit interior to exterior. All component and panel support structure must be internal to AHU. Casing panel inner liners must not extend to the exterior of the unit or contact the exterior frame. A mid-span, no-through-metal, internal thermal break shall be provided for all unit casing panels.

J. Access panels and/or access doors shall be provided in all sections to allow easy access to drain pan, coil(s), motor, drive components and bearings for cleaning, inspection, and maintenance.

K. Access panels and doors shall be fully removable without the use of specialized tools to allow complete access of interior surfaces.

2.04 Access Doors

A. Access doors shall be 2" double-wall construction. Interior and exterior shall be of the same construction as the interior and exterior wall panels.

B. All doors downstream of cooling coils shall be provided with a thermal break construction of door panel and door frame.

C. Gasketing shall be provided around the full perimeter of the doors to prevent

air leakage.

D. Door hardware shall be surface-mounted to prevent through-cabinet penetrations that could likely weaken the casing leakage and thermal performance.

E. Handle hardware shall be designed to prevent unintended closure.

F. Access doors shall be hinged and removable without the use of specialized tools to allow.

G. Hinges shall be interchangeable with the door handle hardware to allow for alternating door swing in the field to minimize access interference due to unforeseen job site obstructions.

H. Door handle hardware shall be adjustable and visually indicate locking position of door latch external to the section.

I. All doors shall be a minimum 60” high when sufficient height is available, or the maximum height allowed by the unit height.

J. Multiple door handles for indoor air handling units shall be provided for each latching point of the door necessary to maintain the specified air leakage integrity of the unit. See Section 2.26 for outdoor air handling unit requirements.

2.05 PRIMARY DRAIN PANS

A. All cooling coil sections shall be provided with an insulated, double-wall, stainless steel drain pan.

B. The drain pan shall be designed in accordance with ASHRAE 62.1 being of sufficient size to collect all condensation produced from the coil and sloped in two planes, pitched toward drain connections, promoting positive drainage to eliminate stagnant water conditions when unit is installed level and trapped per manufacturer's requirements. See section 2.07, paragraph F through H for specifications on intermediate drain pans between cooling coils.

C. The outlet shall be located at the lowest point of the pan and shall be sufficient diameter to preclude drain pan overflow under any normally expected operating condition.

D. All drain pan threaded connections shall be visible external to the unit. Threaded connections under the unit floor shall not be accepted.

E. Drain connections shall be of the same material as the primary drain pan and shall extend a minimum 2-1/2” beyond the base to ensure adequate room for

field piping of condensate traps.

F. The installing contractor is responsible to ensure the unit is installed level, trapped in accordance with the manufacturer's requirements, and visually inspected to ensure proper drainage of condensate.

G. Coil support members inside the drain pan shall be of the same material as the drain pan and coil casing.

H. Drain pans shall be provided for heating coils, access sections, and mixing sections as indicated in the plans.

2.06 FANS

A. Fan sections shall have a minimum of one access door located on the drive side of the unit to allow inspection and maintenance of the fan, motor, and drive components. Construct door(s) per Section 2.04.

B. Provide fans of type and class as specified on the schedule. Fan shafts shall be solid steel, coated with a rust-inhibiting coating, and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. All fans shall be statically and dynamically tested by the manufacturer for vibration and alignment as an assembly at the operating RPM to meet design specifications. Fans controlled by variable frequency drives shall be statically and dynamically tested for vibration and alignment at speeds between 25% and 100% of design RPM. If fans are not factory-tested for vibration and alignment, the contractor shall be responsible for cost and labor associated with field balancing and certified vibration performance. Fan wheels shall be keyed to fan shafts to prevent slipping.

C. Belt-driven fans shall be provided with grease lubricated, self-aligning, anti-friction bearings selected for L-50 200,000-hour average life per ANSI/AFBMA Standard 9. Lubrication lines for both bearings shall be extended to the drive side of the AHU and rigidly attached to support bracket with zerk fittings. Lubrication lines shall be a clear, high-pressure, polymer to aid in visual inspection. If extended lubrication lines are not provided, manufacturer shall provide permanently lubricated bearing with engineering calculations for proof of bearing life.

D. All fans, including direct-drive plenum fans, shall be mounted on spring isolation bases. Internally-mounted motor shall be on the same isolation base. Fan and motor shall be internally isolated with spring isolators. Unit sizes up to nominal 4,000 cfm shall have 1-inch springs. Unit sizes larger than nominal 4,000 cfm shall have 2-inch spring isolators. A flexible connection (e.g. canvas duct) shall be installed between fan and unit casing to ensure complete isolation. Flexible connection shall comply with NFPA 90A and UL 181 requirements. If fans and motors are not internally isolated, then the entire

unit shall be externally isolated from the building, including supply and return duct work, piping, and electrical connections. External isolation shall be furnished by the installing contractor in order to avoid transmission of noise and vibration through the ductwork and building structure.

E. Fan sections containing multiple fans shall be provided as indicated on the schedule and drawings. Each fan shall operate in parallel to each other fan in the array. The fans shall be SWSI plenum type with high efficient AF blades. Fans shall be direct-driven. Fan wheels shall be aluminum. The Hp characteristic of the fans shall be non-overloading.

F. Fan sections containing multiple fans shall be controlled using a common control signal, such as the duct static control signal, to modulate the fan speed.

G. MOTORS AND DRIVES

1. All motors and drives shall be factory-installed and run tested. All motors shall be installed on a slide base to permit adjustment of belt tension. Slide base shall be designed to accept all motor sizes offered by the air-handler manufacturer for that fan size to allow a motor change in the future, should airflow requirements change. Fan sections without factory-installed motors shall have motors field installed by the contractor. The contractor shall be responsible for all costs associated with installation of motor and drive, alignment of sheaves and belts, run testing of the motor, and balancing of the assembly.

2. Motors shall meet or exceed all NEMA Standards Publication MG 1 – 2006 requirements and comply with NEMA Premium efficiency levels when applicable. Motors shall comply with applicable requirements of NEC and shall be UL Listed.

3. Fan Motors shall be heavy duty, NEMA Premium efficient ODP, exceeding the EPAct efficiency requirements.

4. Belt-driven fan sections with single fans shall use 4-pole (1800 rpm) motors, NEMA Class F insulation, with a Class B temperature rise.

5. Direct-driven fan sections shall use 2-pole (3600 rpm), 4-pole (1800 rpm), or 6-pole (1200 rpm) motors, NEMA Design B, with Class B insulation to operate continuously at 104°F (40°C) ambient without tripping of overloads. Multiple fan selections utilizing 8-pole (900 rpm) motors are unacceptable due to motor inefficiency, cost, and replacement lead times.

6. Motors shall have a +/- 10 percent voltage utilization range to protect against voltage variation.

7. **Motors for use with VFD's as listed in the mechanical schedule shall meet the above requirements and shall be Inverter Duty Rated, with an insulation class of F or higher and shall include Shaft grounding brushes AEGIS or equivalent.**

2.07 COILS

A. Coils section side panel shall be removable to allow for removal and replacement of coils without impacting the structural integrity of the unit.

B. Install coils such that headers and return bends are enclosed by unit casing to ensure that if condensate forms on the header or return bends, it is captured by the drain pan under the coil.

C. Coils shall be manufactured with plate fins to minimize water carryover and maximize airside thermal efficiency. Fin tube holes shall have drawn and belled collars to maintain consistent fin spacing to ensure performance and air pressure drop across the coil as scheduled. Tubes shall be mechanically expanded and bonded to fin collars for maximum thermal conductivity. Use of soldering or tinning during the fin-to-tube bonding process is not acceptable due to the inherent thermal stress and possible loss of bonding at that joint.

D. Construct coil casings of galvanized steel. End supports and tube sheets shall have belled tube holes to minimize wear of the tube wall during thermal expansion and contraction of the tube.

E. All coils shall be completely cleaned prior to installation into the air handling unit. Complete fin bundle shall be degreased and cleaned to remove any lubricants used in the manufacturing of the fins, or dirt that may have accumulated, in order to minimize the chance for water carryover.

F. When two or more cooling coils are stacked in the unit, an intermediate drain pan shall be installed between each coil. The intermediate drain pan shall be designed being of sufficient size to collect all condensation produced from the coil and sloped to promote positive drainage to eliminate stagnant water conditions. The intermediate drain pan shall be constructed of the same material as the primary drain pan.

G. The intermediate drain pan shall begin at the leading face of the water-producing device and be of sufficient length extending downstream to prevent condensate from passing through the air stream of the lower coil.

H. Intermediate drain pan shall include downspouts to direct condensate to the primary drain pan. The intermediate drain pan outlet shall be located at the lowest point of the pan and shall be sufficient diameter to preclude drain pan overflow under any normally expected operating condition.

I. Hydronic Coils

1. Supply and return header connections shall be clearly labeled on unit exterior such that direction of coil water-flow is counter to direction of unit air-flow.

2. Coils shall be proof-tested to 300 psig and leak-tested to 200 psig air pressure under water.

3. Headers shall be constructed of round copper pipe or cast iron.

4. Tubes shall be 1/2 inch O.D., minimum. Fins shall be aluminum.

4. Hydronic coils shall be supplied with factory installed drain and vent piping to the unit exterior.

2.07 FILTERS

A. Provide factory-fabricated filter section of the same construction and finish as unit casings. Filter section shall have side access filter guides and access door(s) extending the full height of the casing to facilitate filter removal. Construct doors in accordance with Section 2.04. Provide fixed filter block offs as required to prevent air bypass around filters. Block offs shall not need to be removed during filter replacement. Filters to be of size and quantity required to maximize filter face area for each air handling unit.

A. Filter type, MERV rating, and arrangement shall be provided as defined in project plans and schedule.

B. Contractor shall provide one complete set of MERV 8 startup filters in-unit, and at/on each return grille during construction. Contractor shall provide one complete set of MERV 8 pre-filters, and one complete set of MERV 8 final filters installed after construction and clean-up and prior to Test-and-Balance, and Occupancy.

2.09 DAMPERS

A. All dampers, with the exception of external bypass and multizones (if scheduled), shall be internally mounted. Dampers shall be premium ultra-low leak and located as indicated on the schedule and plans. Blade arrangement (parallel or opposed) shall be provided as indicated on the schedule and drawings. Dampers shall be Greenheck VCD-33 or Ruskin CD60 double-skin airfoil design or equivalent for minimal air leakage and pressure drop. Leakage rate shall not exceed 3 CFM/square foot at one inch water gauge complying with ASHRAE 90.1 maximum damper leakage and shall be AMCA licensed for Class 1A. All leakage testing and pressure ratings shall be based on AMCA Standard 500-D. Dampers shall include bronze bearings and Manufacturer

shall submit brand and model of damper(s) being furnished, if not as specified above.

2.10 ACCESS SECTIONS

A. Access sections shall be provided where indicated in the schedule and plans to allow additional access for inspection, cleaning, and maintenance of unit components. The unit shall be installed for proper access. Procedure for proper access, inspection and cleaning of the unit shall be provided in the AHU manufacturer's maintenance manual. Access section doors shall be constructed per Section 2.04.

2.11 INTERNAL FACE AND BYPASS SECTIONS (AH-2A and AH-2B)

A. Dampers shall be provided as indicated on the schedule and plans to divert airflow around the coil internally within the air handling unit. Dampers shall be low leak and opposed blade arrangement. Dampers shall be Greenheck VCD-33 or Ruskin CD60 double-skin airfoil design or equivalent for minimal air leakage and pressure drop. Leakage rate shall not exceed 5 CFM/square foot at one inch water gauge. All leakage testing and pressure ratings shall be based on AMCA Standard 500-D. Dampers shall include bronze bearings and Manufacturer shall submit brand and model of damper(s) being furnished, if not as specified above.

2.12 INTEGRAL FACE AND BYPASS COIL SECTION

A. Integral face and bypass coils shall be provided as indicated on the schedule and drawings. Coils shall consist of a built-in series of finned heating, and bypass areas, with mechanically interlocked dampers. Coils shall be constructed of 14-gage galvanized steel with fins no less than 0.010-inch thick aluminum and copper tubing a minimum 0.035-inch thick. Coils shall be certified to and bear the AHRI 410 Standard label.

B. Dampers shall be arranged to completely enclose and isolate heating elements. Coils shall include mixing baffles to minimize downstream mixing distance to 24-inches. At minimum distance, leaving air temperature shall vary no more than +/- 5 deg F from the average leaving air temperature.

C. Manufacturer shall extend coil connections on horizontal-tube coils through the unit casing wall to facilitate piping. Coil connection penetrations through unit casing shall be provided by unit manufacturer on vertical-tube coils. Installing contractor shall be responsible for providing flexible connector on return header and supply/return piping through unit casing wall.

2.13 DISCHARGE PLENUM SECTIONS

A. Plenums shall be provided as indicated in the schedule and plans to efficiently

turn air and provide acoustical attenuation. Discharge plenum opening types and sizes shall be scaled to meet pressure drop requirements scheduled and align with duct takeoffs.

B. Discharge plenum panels shall include an acoustical liner where indicated in the schedule and plans to meet acoustical requirements. The liner shall be fabricated from stainless steel perforated material to prevent corrosion and designed to completely encapsulate fiberglass insulation. The perforation spacing and hole size shall be such as to prevent insulation breakaway, flake off, or delamination when tested at 9000 fpm, in accordance with UL 181 or ASTM C1071. Insulation material must be resistant to fungi in accordance with ASTM C1338.

2.14 TOTAL ENERGY RECOVERY WHEEL SECTIONS (MAU-1)

A. Total energy recovery wheels shall be provided as indicated on the schedule and drawings. Wheels shall be integral parts of the AHUs and shall be sized per the ventilation requirement of the units. Additional outside air units, or other field assembled and ducted energy recovery devices, are not acceptable. Mixed air units with economizing shall be constructed with internal bypass dampers such that the pressure drop across the wheel does not increase during economizing. External bypass and multiple duct connections are not acceptable.

B. The air handling unit shall be certified by AHRI to contain a rotary energy recovery wheel certified to ANSI/AHRI Standard 1060 and bears the AHRI 1060 label. The air handling unit and wheel must be AHRI 1060-certified as a package. Proof of compliance shall be that the air handling unit brand name and specific wheel being used be listed on the AHRI website within the Directory of Certified Product Performance for Commercial Air-to-Air Energy Recovery Ventilators under the Packaged Program Type. Verification of performance for non-AHRI 1060 certified AHU packages shall be completed by witness test for the owner/owner's representative and specifying engineer at the jobsite. Installing contractor shall be responsible for all expenses of verification testing, including test set-up, room/board for owner/owner's representative and engineer, travel to and from the jobsite, as well as modification costs associated to achieving specified performance.

C. Performance characteristics of the energy wheel shall be provided as defined by AHRI 1060 definitions. The energy wheel shall be a total energy wheel, with the sensible and latent effectiveness reported and within 5% of each other. The calculated total net effectiveness of the recovery wheel shall not be less than 70% when the specified ventilation flow rate equals the exhaust flow rate. The energy wheel's EATR shall be less than the value indicated in the schedule and drawings. Wheel face velocity and pressure drop shall not exceed performance as defined on schedule. The energy recovery cassette shall be an Underwriters Laboratories (UL) Recognized Component certified for mechanical, electrical, and fire safety in accordance with UL Standard

1812.

D. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belts. The total energy recovery wheel shall incorporate a desiccant without the use of binders or adhesives, which may plug the desiccant aperture. The adsorbent shall not be applied as a glued on surface coating and not susceptible to erosion, abrasion, or delamination. Coated segments shall be washable using standard detergent or alkaline-based coil cleaners. The adsorbent shall be selected for its high affinity for water vapor and shall not dissolve or deliquesce in the presence of water or high humidity. The rim shall be continuous rolled stainless steel to form an even concentric circle to prevent leakage around the rim and to minimize wear of components. All diameter and perimeter seals shall be provided as part of the cassette assembly. Perimeter seals shall be self-adjusting; diameter seals shall be adjustable. Seals shall be factory set.

E. Wheel drive motor shall be provided mounted in the cassette frame. Wheel drive motor shall be thermally protected and UL Component Recognized. Drive belts shall not require belt tensioners. On units that require drive belt tensioners for the wheel belt/motor assembly, the unit manufacturer shall provide at no additional charge to the customer a visual inspection every four months, and adjustment if necessary, of the recommended belt tension during the unit warranty period. Wheel motors shall be of the voltage, phase, frequency, and Hp indicated on the schedule and drawings.

F. Wheel bearings shall be permanently sealed and lubricated and have a minimum L-10 life of 400,000 hours.

G. Access doors shall be provided for the removal of wheel segments. Doors shall be located on all air entering and air leaving sides of wheel to allow access to the entire upstream and downstream face of each wheel. Adequate space and access shall be provided for energy wheel motor, bearing and belt removal. Access doors shall be constructed per Section 2.04.

H. Energy recovery wheels shall be designed with variable effectiveness control, to vary the wheel's recovery capacity. Variable effective control shall be done by an internal bypass damper provided by the AHU Manufacturer. The wheel's variable effectiveness control shall have the ability to modulate the total energy recovery ability down to at least 40% of the initial recovery capacity. Variable frequency speed control is not an acceptable method for controlling variable effectiveness.

I. Frost prevention shall be achieved by outside air bypass, return air preheat, or outside air preheat, depending upon design conditions. Frost set point temperatures based on the scheduled design air conditions shall be provided by the AHU Manufacturer. Variable frequency speed control is not an acceptable method of frost control. Winter design supply and exhaust air

conditions leaving the energy wheel shall be provided by the AHU Manufacturer and shall include any de-rate in performance due to frost prevention measures.

J. Control of energy wheels shall be incorporated and an integral part of the AHU control systems and shall be as described under the AHU control specifications. Secondary independent wheel controllers are not acceptable.

K. Provide energy wheel by-pass with dampers located on the exhaust air section of the energy recovery wheel.

2.15 OUTDOOR AIR HANDLING UNITS

A. In addition to all other details specified within for air handling units, units that are installed outdoors shall also comply with the following sections. Outdoor air handling units shall have only single door handles for each door linking multiple latching points necessary to maintain the specified air leakage integrity of the unit and ease of maintenance. Outdoor AHUs shall be shipped with all openings covered to protect unit interior from in-transit debris.

B. Unit Paint

1. External surfaces of all outdoor unit casings shall be prepared and painted with a minimum 1.5 mil thick enamel finish or equal. Paint shall be able to withstand a salt spray test in accordance with ASTM B117 for a minimum of 500 consecutive hours. Paint shall be AHU Manufacturer's standard color, unless otherwise indicated in the schedule and drawings.

C. Unit Base

1. Outdoor units shall have a 6-inch welded base and steel cross members for structural rigidity and supports the full perimeter of the air handling unit. AHU panels must overhang the primary unit base such that no ledge exists for water to pool. The entire AHU perimeter shall be sealed for additional water management protection. A drain pan under the entire unit or sections shall not be an acceptable alternative to prevent water from entering the building space.

2. Unit base shall be designed to allow the unit to be either pier-mounted or rest on a roof curb when field-installed as indicated on the schedule and drawings.

D. Unit Roof

1. Outdoor unit roofs shall incorporate a standing seam on the exterior to ensure a rigid roof construction and prevent water infiltration. Roof

assembly shall overhang all walls by 1.5-inch minimum to prevent sheeting from roof to side panels. Rain gutters shall also be provided over all doors to direct rain away from the door assembly.

2. Outdoor roofs shall be sloped, not less than 0.125 inches per foot, for water drainage. Where outdoor units are shipped in multiple sections, provide standing-seam joiners at each split with adhesive, hardware, and cover strips for field joining by the installing contactor.

E. Weather Hoods

1. Outside and exhaust air weather hoods shall be fabricated from the same material as the unit exterior. Hoods shall extend past the perimeter of the unit casing opening to ensure the hood does not obstruct the airflow path. Hoods shall be painted with the same paint requirements identified for the external casing herein.

2. Inlet hoods for each outside damper shall be provided with a high performance sine-wave moisture eliminator to prevent entrainment of water into the unit from outside air. Wire mesh screens shall not be acceptable as a moisture eliminator. Exhaust hoods shall be provided on exhaust air openings.

3. All hoods shall be sized for 100 percent of nominal damper capacities and furnished with bird screens or similar protection to prevent nesting and entry into AHU inlet or exhaust paths.

F. Roof Curbs

1. Roof curbs shall be provided where indicated on the plans and shall be galvanized steel. Roof curb shall support the full perimeter of the air handling unit, including pipe chases.

2. A 2”x4” nominal wood nailing strip shall be supplied attached to the roof curb. Wood nailing strip shall be of #4 Spruce or #4 Yellow Pine.

3. Roof curb shall include frame work necessary to support supply and return duct installation prior to unit placement.

4. Roof curb shall be shipped loose for field installation prior to unit placement.

2.16 MARINE LIGHTS

A. Marine lights shall be provided throughout AHUs as indicated on the schedule and plans. Lights shall be instant-on, light-emitting diode (LED) type to minimize amperage draw and shall produce lumens equivalent to a minimum

75W incandescent bulb (1200 lumens). LED lighting shall provide instant-on, white light and have a minimum 50,000 hr life.

B. Light fixture shall be weather-resistant, enclosed and gasketed to prevent water and dust intrusion.

C. Fixtures shall be designed for flexible positioning during maintenance and service activities for best possible location providing full light on work surface of interest and not being blocked by technician.

D. All lights on a unit shall be wired in the factory to a single on-off switch.

E. Installing contractor shall be responsible for providing 115V supply to the factory-mounted marine light circuit.

PART 3 EXECUTION

3.01 SHIPPING

A. Paper copies of the IOM shall also be shipped with each AHU.

B. The AHU manufacturer shall identify all shipments with the order number. Enough information shall be provided with each shipment to enable the Mechanical Contractor to confirm the receipt of units when they are received. For parts too small to mark individually, the AHU manufacturer shall place them in containers.

C. To protect equipment during shipment and delivery, all indoor units shall be completely stretch or shrink wrapped. Wrap shall be a minimum of 7 mil plastic. Pipe ends and pipe connection holes in the casing shall be capped or plugged prior to shipment.

D. After loading the equipment for shipment, the AHU manufacturer shall contact the shipping contact on the order and provide the name of the carrier, description of equipment, order number, shipping point, and date of shipment.

3.02 ON-SITE STORAGE

A. If equipment is to be stored for a period of time prior to installation, the Mechanical Contractor shall remove all stretch or shrink wrap from units upon receipt to prevent unit corrosion and shall either place the units in a controlled indoor environment or shall cover the units with canvas tarps and place them in a well-drained area. Covering units with plastic tarps shall not be acceptable.

3.03 FIELD EXAMINATION

A. The Mechanical Contractor shall verify that the mechanical room and/or roof are ready to receive work and the opening dimensions are as indicated on the shop drawings and contract documents.

B. The Mechanical Contractor shall verify that the proper power supply is available prior to starting of the fans.

3.04 INSTALLATION

A. The Mechanical Contractor shall be responsible to coordinate ALL installation requirements with the Owner and the Owner's selected Mechanical Contractor to ensure that a complete installation for each unit is being provided. Coordination efforts shall include such items as unloading and hoisting requirements, field wiring requirements, field piping requirements, field ductwork requirements, requirements for assembly of field-bolted or -welded joints, and all other installation and assembly requirements.

B. The AHU manufacturer shall provide all screws and gaskets for joining of sections in the field.

C. The Mechanical Contractor shall verify that the following items have been completed prior to scheduling the AHU manufacturer's final inspection and start up:

1. All spring-isolated components have had their shipping restraints removed and the components have been leveled.

2. On all field-joined units, that all interconnections have been completed, i.e., electrical and control wiring, piping, casing joints, bolting, welding, etc.

3. All water and steam piping connections have been completed and hydrostatically tested and all water flow rates have been set in accordance with the capacities scheduled on the Drawings.

4. All ductwork connections have been completed and all ductwork has been pressure tested for its intended service.

5. All power wiring, including motor starters and disconnects, serving the unit has been completed.

6. All automatic temperature and safety controls have been completed.

7. All dampers are fully operational.

8. All shipping materials have been removed.

9. All (clean) filter media has been installed in the units.

3.05 LEVELING

A. The Mechanical Contractor shall level all unit sections in accordance with the unit manufacturer's instructions. The Mechanical Contractor shall provide and install all necessary permanent shim material to ensure individual sections and entire assembled units are level.

3.06 FINAL INSPECTION AND START UP SERVICE

A. After the Mechanical Contractor has provided all water and steam piping connections, ductwork connections, and field control wiring, and Electrical Contractor has provided all the field power wiring, the Mechanical Contractor shall inspect the installation. The Mechanical Contractor shall then perform startup of the equipment.

B. The Automatic Temperature Control (Building Direct Digital Control) Contractor shall be scheduled to be at the job site at the time of the equipment start up.

C. The Mechanical Contractor, shall perform the following tests and services and submit a report outlining the results:

1. Record date, time, and person(s) performing service.

2. Lubricate all moving parts.

3. Check all motor and starter power lugs and tighten as required.

4. Verify all electrical power connections.

5. Conduct a startup inspection per the AHU manufacturer's recommendations.

6. Record fan motor voltage and amperage readings.

7. Check fan rotation and spin wheel to verify that rotation is free and does not rub or bind.

8. Check fan for excessive vibration.

9. Check V belt drive or coupling for proper alignment.

10. Check V belt drive for proper tension. Tighten the belts in accordance with the AHU manufacturer's directions. Check belt tension during the second and seventh day's operation and re-adjust belts, as may be

required, to maintain proper tension as directed by the AHU manufacturer.

11. Remove all foreign loose material in ductwork leading to and from the fan and in the fan itself.

12. Disengage all shipping fasteners on vibration isolation equipment.

13. Check safety guards to insure they are properly secured.

14. Secure all access doors to the fan, the unit and the ductwork.

15. Switch electrical supply "on" and allow fan to reach full speed.

16. Physically check each fan at start up and shut down to insure no abnormal or problem conditions exist.

17. Check entering and leaving air temperatures (dry bulb and wet bulb) and simultaneously record entering and leaving chilled water temperatures and flow, steam pressures and flow, and outside air temperature.

18. Check all control sequences.

PART 4 SEQUENCE OF OPERATIONS

4.01 END OF SECTION

END OF SECTION

SECTION 23 81 23
GUIDE SPECIFICATIONS
Computer Room Air Conditioning Equipment
Chilled Water Environmental Control Systems

1.0 GENERAL

1.1 SUMMARY

These specifications describe requirements for a precision environmental control system. The system shall be designed to maintain temperature conditions in the rooms containing electronic equipment.

The manufacturer shall design and furnish all equipment to be fully compatible with heat dissipation requirements of the room.

1.2 DESIGN REQUIREMENTS

The precision environmental control system shall be a Liebert self-contained factory assembled unit with upflow air delivery. The system shall have a *total cooling capacity and sensible cooling capacity based on an entering air temperature per plans*. The unit is to be supplied with 460 volt, 3 phase, 60 Hertz electrical service.

1.3 SUBMITTALS

Submittals shall be provided with the proposal and shall include: Single-Line Diagrams; Dimensional, Electrical, and Capacity Data; Piping and Electrical Connection Drawings.

2.0 PRODUCT

2.1 CABINET AND FRAME CONSTRUCTION

The frame shall be constructed of heliarc welded tubular steel. It shall be painted using the autophoretic coating process for maximum corrosion protection. The exterior panels shall be insulated with a minimum 1 in., 1.5 lb. density fiber insulation. The main front panel shall have captive 1/4 turn fasteners. The main unit color shall be IBM Charcoal Gray (Z-0420). The accent color shall be IBM Charcoal Gray (Z-0420). The exterior panels shall be powder coated.

2.2 FILTERS

The unit filters shall be located in the return air grilles where indicated in the contract documents. The filters shall be rated not less than MERV8 (based on ASHRAE 52.2). Provide with (2) sets, one used during construction, and one set installed prior to test and balance and occupancy.

2.3 FAN

The supply fan(s) shall be dynamically balanced. The drive package shall be direct drive or belt drive for variable speed operation. The fans shall be located to draw air over the A-frame coil to ensure even air distribution and maximum coil performance

2.4 ELECTRICAL SHORT CIRCUIT RATING

The chilled water system shall be designed with electrical components to deliver a 65,000 amps rms Short Circuit Current Rating.

2.5 REHEAT

The environmental control unit shall include a factory-installed reheat to control temperature during dehumidification.

2.5.1 Three-Stage Electric Reheat

The electric reheat coils shall be low watt density, 304/304 stainless steel fin tubular construction, protected by thermal safety switches, rated for kW *per plans*, and controlled in three stages. The reheat elements shall be removable from the front of the cabinet. The coils shall provide non-ionizing heat at a maximum sheath temperature not exceeding 420°F.

2.5 HUMIDIFIER

A humidifier shall be factory-installed inside the unit. Bypass air slots shall be included to enable moisture to be absorbed into the air stream. The humidifier capacity shall be 17.4 lbs. per hour. The humidifier shall be removable from the front of the cabinet.

2.5.1 Infrared Humidifier

The humidifier shall be of the infrared type consisting of high intensity quartz lamps mounted above and out of the water supply. The humidifier pan shall be stainless steel and arranged to be removable without disconnecting high voltage electrical connections. The complete humidifier section shall be pre-piped, ready for field connection to water supply. The humidifier shall be equipped with an automatic water supply system and shall have an adjustable water-overfeed to prevent mineral precipitation. A high-water detector shall shut down the humidifier to prevent overflowing. A factory-provided air-gap shall prevent backflow of the humidifier supply water. Refer to Plumbing Plans for Humidifier RO system.

2.6 LIEBERT ICOM™ MICROPROCESSOR CONTROL WITH SMALL GRAPHIC DISPLAY

The Liebert iCOM unit control shall be factory-set for Intelligent Control which uses “fuzzy logic” and “expert systems” methods. Proportional and Tunable PID shall also be user selectable options. Internal unit component control shall include the following:

System Auto Restart - The auto restart feature will automatically restart the system after a power failure. Time delay is programmable.

Sequential Load Activation - On initial startup or restart after power failure, each operational load is sequenced with a minimum of one second delay to minimize total inrush current.

Hot Water Flush Cycles - Hot water reheat coils and Econ-O-Coils are periodically flushed to prevent a buildup of contaminants.

Predictive Humidity Control - calculates the moisture content in the room and prevents unnecessary humidification and dehumidification cycles by responding to changes in dew point temperature.

The Liebert iCOM control shall be compatible with Liebert remote monitoring and control devices. Options are available for BMS interface via MODbus, Jbus, BACNet, Profibus and SNMP.

The Liebert iCOM control processor shall be microprocessor based with a dot matrix graphic front monitor display and control keys for user inputs mounted in an ergonomic, aesthetically pleasing housing. The display & housing shall be viewable while the unit panels are open or closed. The controls shall be menu driven. The display shall be organized into three main

sections: User Menus, Service Menus and Advanced Menus. The system shall display user menus for: active alarms, event log, graphic data, unit view/status overview (including the monitoring of room conditions, operational status in % of each function, date and time), total run hours, various sensors, display setup and service contacts. A password shall be required to make system changes within the service menus. Service menus shall include: setpoints, standby settings (lead/lag), timers/sleep mode, alarm setup, sensor calibration, maintenance/wellness settings, options setup, system/network setup, auxiliary boards and diagnostics/service mode. A password shall be required to access the advanced menus which include the factory settings and password menus.

The User Menus shall be defined as follows:

Active Alarms: Unit memory shall hold the 200 most recent alarms with time and date stamp for each alarm.

Event Log: Unit memory shall hold the 400 most recent events with ID number, time and date stamp for each event.

Graphic Data View: Eight graphic records shall be available: return air temperature, return air humidity, supply air temperature, outdoor temperature and four custom graphs.

Unit View: Status Overview: Simple or Graphical “Unit View” summary displays shall include temperature and humidity values, active functions (and percent of operation) and any alarms of the host unit.

Total Run Hours: Menu shall display accumulative component operating hours for major components including fan motor, humidifier and reheat.

Various Sensors: Menu shall allow setup and display of optional custom sensors. The control shall include four customer accessible analog inputs for sensors provided by others. The analog inputs shall accept a 4 to 20mA signal. The user shall be able to change the input to 0 to 5VDC or 0 to 10VDC if desired. The gains for each analog input shall be programmable from the front display. The analog inputs shall be able to be monitored from the front display.

Display Setup: Customer shall pre-select the desired grouping of display languages at the time of the order from the following choices:

Group 1: English, French, Italian, Spanish, German

Group 2: English, Russian, Greek

Group 3: English, Japanese, Chinese, Arabic

Service Contacts: Menu shall allow display of local service contact name and phone number.

The Service Menus shall be defined as follows:

Setpoints: Menu shall allow setpoints within the following ranges:

- Temperature Setpoint 65-85ºF*
- Temperature Sensitivity +1-10ºF
- Humidity Setpoint 20-80% RH*
- Humidity Sensitivity 1-30% RH
- High Temperature Alarm 35-90ºF
- Low Temperature Alarm 35-90ºF
- High Humidity Alarm 15-85% RH
- Low Humidity Alarm 15-85% RH

** The microprocessor may be set within these ranges, however, the unit may not be able to control to extreme combinations of temperature and humidity.*

Standby Settings/Lead-Lag: Menu shall allow planned rotation or emergency rotation of operating and standby units.

Timers/Sleep Mode: Menu shall allow various customer settings for turning on/off unit.

Alarm Setup: Menu shall allow customer settings for alarm notification (audible/local/remote). The following alarms shall be available:

- High Temperature
- Low Temperature
- High Humidity
- Low Humidity
- Main Fan Overload
- Humidifier Problem
- Change Filter
- Fan Failure
- Unit Off

Audible Alarm: The audible alarm shall annunciate any alarm that is enabled by the operator.

Common Alarm: A programmable common alarm shall be provided to interface user selected alarms with a remote alarm device.

Remote Monitoring: All alarms shall be communicated to the Liebert monitoring system (if available) with the following information: Date & time of occurrence, unit number & present temperature & humidity.

Sensor Calibration: Menu shall allow unit sensors to be calibrated with external sensors.

Maintenance/Wellness Settings: Menu shall allow reporting of potential component problems before they occur.

Options Setup: Menu shall provide operation settings for the installed components.

System/Network Setup: Menu shall allow Unit-to-Unit (U2U) communication and setup for teamwork modes of operation (up to 32 units).

Teamwork Modes of Operation: Saves energy by preventing operation of units in opposite modes multiple units.

Auxiliary Boards: Menu shall allow setup of optional expansion boards.

Diagnostics/Service Mode: The Liebert iCOM control shall be provided with self-diagnostics to aid in troubleshooting. The microcontroller board shall be diagnosed and reported as pass/not pass. Control inputs shall be indicated as on or off at the front display. Control outputs shall be able to be turned on or off from the front display without using jumpers or a service terminal. Each control output shall be indicated by an LED on a circuit board.

Advanced Menus

Factory Settings: Configuration settings shall be factory-set based on the pre-defined component operation.

Change Passwords: Menu shall allow new passwords to be set or changed.

2.6.1 Liebert iCOM Microprocessor Control With Large Graphic Display

The Liebert iCOM unit control with large graphic display shall include all of the features as the Liebert iCOM with small graphic display, except that it includes a larger graphical display and shall include the additional features of:

“System View”, Spare Parts List, Unit Diary.

The Liebert iCOM control processor shall be microprocessor based with a 320x240 dot matrix graphic front monitor display panel and control keys for user inputs mounted in an ergonomic, aesthetically pleasing housing.

System View - Status Overview: “System View” shall display a summary of operation for the total number of operating units within a Unit-to-Unit (U2U) configuration.

Spare Parts List: Menu shall include a list of critical spare parts, their quantity and part numbers.

Unit Diary: Menu shall include a free field area within the unit memory where unit history may be stored for reference.

2.7 RETURN AIR SENSORS

The unit shall have factory-provided temperature & humidity sensors mounted in the return air stream. These sensors are the standard control interface with the Liebert iCOM control system. However, if an optional supply air sensor is connected to the unit, the return air sensors will be used by iCOM to sense and maintain the humidity setpoint in the conditioned space while the optional supply air sensor will be used by iCOM to sense and control the temperature setpoint in the conditioned space.

2.8 CHILLED WATER CONTROL VALVES

There shall be a 3-way modulating valve. The valve shall be rated for 400 psi maximum operating pressure. The Liebert iCOM positions the valves in response to room conditions.

2.9 A-FRAME CHILLED WATER COIL

The cooling coil shall be of A-frame design. The coil shall be controlled by a 3-way modulating control valve. It shall be constructed of copper tubes and aluminum fins and have a maximum face velocity of 450 ft. per minute at design airflow.

The water circuit shall be designed to distribute water into the entire coil face area. The coil shall be supplied with 44°F entering water temperature, with a 14°F temperature rise. The entire coil assembly shall be mounted in a stainless steel condensate drain pan.

2.10 OPTIONAL COMPONENTS

The computer room environmental control system shall be equipped with the following optional components.

2.10.1 Disconnect Switch—Locking Type

The manual disconnect switch shall be mounted in the high voltage section of the electrical panel. The switch shall be accessible from the outside of the unit with the door closed, and prevent access to the high voltage electrical components until switched to the “OFF” position.

2.10.2 Condensate Pump, Dual Float

The pump has capacity of 6 GPM at 20 ft. head. The pump is complete with integral dual float switch, pump, motor assembly, and reservoir. The secondary float shall send a signal to the local alarm and shut down the unit upon high water condition.

2.10.5 Main Fan Auxiliary Switch

The main fan auxiliary switch provides the unit with one Normally Open set of contacts to indicate that the fan contactor has the fans in the “On” position.

2.10.6 Main Fan Overload Alarm

The main overload alarm activates an alarm or digital readout on the front monitor panel to indicate a fan overload condition.

2.10.7 Low Voltage Terminal Package –

The Low Voltage Terminal Package includes the following items:

2.10.7.1 Two (2) Additional Remote Shutdown Terminals, providing the customer with a total of three (3) locations to remote shut down the unit.

2.10.7.2 Two (2) Extra Common Alarm Contacts, providing the customer with a total of three (3) Normally Open contacts for remote indication of unit alarms.

2.10.9 Supply Air Temperature Sensor

An optional supply air temperature sensor shall be provided to sense the unit's discharge air temperature and to open and close the unit's chilled water valve as needed to maintain the set point temperature in the conditioned space.

2.10.10 Smart Aisle Controls

SmartAisle Control algorithms control the unit fan speed and chilled water valve position independent of one another to properly supply only the correct amount of capacity and airflow to a server rack. The algorithms reside in each iCOM board and are selectable in the service menu. SmartAisle Controls require a supply air temperature sensor and 2T sensors installed on the rack inlets in the zone to be controlled. The 2T sensors must be connected by a daisy chain CANbus communication wire to the Liebert CW iCOM unit controller. The 2T sensors, CANbus wiring and supply air temperature sensors are installed in the field.

2.10.10.1 2T Sensor Kits - Each 2T Sensor kit contains a single 2T sensor with two temperature probes, ground ring with CANbus cable and labels for the sensor.

2.10.10.2 CANbus Cables - The CANbus cables are used to communicate information from 2T sensors to the iCOM main control panel. The cables are shielded, grounded, and plenum rated, available in common lengths from 3 ft. to 150 ft. long.

2.10.10.3 Rack Temperature Sensors - 2T rack temperature sensors consist of a vented case with two temperature probes. The sensors shall provide real-time, direct feedback to the cooling unit to optimize the amount of cooling and airflow provided. The sensor data shall be available to remote BMS and monitoring systems. The sensor network shall consists of one CANbus wire leaving the cooling unit and connecting to a 2T sensor. Each remaining 2T sensor is connected to the previous sensor. See the project drawings for the number of 2T sensors and CANbus wire lengths & quantities required.

2.10.11 IntelliSlot Web Card (IS-IPBML)

Hot-swappable card shall reside in IntelliSlot communications enclosure section of the unit's iCOM controls and provide communications via the following protocols: HTTP, HTTPS, Telnet, Modbus IP, BACnet IP, and Liebert's proprietary protocol.

3.0 EXECUTION

3.1 INSTALLATION OF PRECISION COOLING UNITS

3.1.1 General

Install precision cooling units in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

3.1.2 Electrical Wiring

Install and connect electrical devices furnished by manufacturer but not specified to be factory mounted. Furnish copy of manufacturer's electrical connection diagram submittal to electrical contractor.

3.1.3 Piping Connections

Install and connect devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's piping connection diagram submittal to piping contractor.

3.2 FIELD QUALITY CONTROL

Start up cooling units in accordance with manufacturer's warranty inspection & user manual instructions. Test controls and demonstrate compliance with requirements as described in iCOM CONTROL & SEQUENCE OF OPERATION. Provide field start-up and training by an authorized factory technician.

SECTION 23 81 24

COMPUTER ROOM AIR CONDITIONING ICOM SYSTEM

PART 1 - GENERAL

1.1 Environmental control units iCOM smart aisle control, CRAC units 1 & 2

A. Each CRAC Unit shall be provided with an iCOM micropressor with large graphic display. iCOM controls shall include Smart Aisle Control using up to 20 Rack Temperature sensors (10-2T Modules), normal return air temperature/humidity board (for dew point control) and a separate temperature sensor in the supply discharge air to adjust to chilled water valve actuator.

B. The control system shall include the following:

1. Proportional control in response to room temperature and humidity.
2. Built in lead-lag functions
3. Service alerts to present problems
4. Unit-to-Unit communications to keep two (2) units in each system to work together
5. Status menu showing setpoints, environmental conditions, operational status alarm conditions and system health.
6. Graphic viewers
7. Display Icons
8. Access levels – user, service, advanced
9. Help menu layout
10. Temperature and humidity graphs
11. Event log
12. Standby, lead & lag
13. Spare parts list
14. Unit diary
15. View status
16. Control of all cooling units
17. View system averages of system network
18. Control of fan speed and capacity
19. Variable speed drive package
20. Bacnet Interface

C. The iCOM microprocessor shall also include the following:

1. System auto restart after power failure

2. Sequenced restart after power failure

3. Predictive humidity (dew point) control and dehumidification control and reheat

4. BAS interface with the following options:
   a. BACnetIP or ModbusIP (*provide*)
   b. Modbus RTU (485)

c. SNMP, SMS, SMTP and HTTP

5. User menu, service menu and advanced menu display

6. User Menu: active alarm, event log, graphic data unit view/status override, run hours, sensors display setup and service contracts.

7. Service menu shall include: setpoints, standby settings (lead lag), timers/sleep mode, alarm setup, sensor calibration, maintenance/wellness settings, options setup, system/network setup, auxiliary boards and diagnostics/service mode. A password will be required to access the advance menus which include the factory settings and password menus.

D. The User Menu Shall be defined as follows:

1. Active Alarms: Unit memory shall hold the 200 most recent alarms with time and date stamp for each alarm.

2. Graphic Data View: 2 graphic records shall be provided, the controlling sensor for temperature and the Dew point / RH%.

3. Unit View: Status Overview: Simple or Graphical “Unit View” summary displays shall include temperature and humidity values, active functions (and percent of operation) and any alarms of the host unit.

4. Total Run Hours: Menu shall display accumulative component operating hours for major components including fan motor and reheat.

5. Various Sensors: Menu shall allow setup and display of optional custom sensors. Chilled Water Units shall include up to 4 analog inputs. The analog inputs shall accept a 4 to 20mA signal. The user shall be able to change the input to 0 to 5VDC or 0 to 10VDC if desired. The gains for each analog input shall be programmable from the front display.

6. Display Setup: Customer shall pre-select the desired grouping of display languages:

a. Group 1: English, French, Italian, Spanish, German
b. Service Contacts: Menu shall allow display of local service contact name and phone number.

7. The Service Menus Shall be defined as follows:

Setpoints: Menu shall allow setpoints within the following ranges:

a. Temperature Setpoint 65°F to 85°F
b. Temperature Sensitivity +1 - 10°F
c. High Humidity Setpoint 20 - 80% RH*
d. Humidity Sensitivity 1 – 30% RH
e. High Temperature Alarm 35 - 90°F
f. Low Temperature Alarm 35 – 90%

g. High Humidity Alarm 15 – 85% RH

**The microprocessor may be set within these ranges, however, the unit may not be able to control to extreme combinations of temperature and humidity.*

8. Standby Settings/Lead-Lag: Menu shall allow planned rotation or emergency rotation of operating and standby units.

9. Alarm Setup: Menu shall allow customer settings for alarm notification (audible/local/remote). The following alarms shall be available:

   a. High Temperature
   b. Low Temperature
   c. High Humidity
   d. Main Fan Overload
   e. Change Filter
   f. Fan Failure
   g. Unit Off
   h. Loss of Airflow
   i. Loss of Power

10. Audible Alarm: The audible alarm shall annunciate any alarm that is enabled by the operator.

11. Common Alarm: A programmable common alarm shall be provided to interface user selected alarms with a remote alarm device.

12. Remote Monitoring: All alarms shall be communicated to the Liebert monitoring system (if available) with the following information: Date and time of occurrence, unit number and present temperature and humidity.

13. Sensor Calibration: Menu shall allow unit sensors to be calibrated with external sensors.

14. Maintenance/Wellness Settings: Menu shall allow reporting of potential component problems before they occur.

15. Options Setup: Menu shall provide operation settings for the installed components.

16. System/Network Setup: Menu shall allow Unit-to-Unit (U2U) communication and setup for teamwork modes of operation (maximum of 32 units) using owner-provided network switch.

17. Teamwork Modes of Operation: Saves energy by preventing operation of units in opposite modes multiple units.

18. Auxiliary Boards: Menu shall allow setup of optional expansion boards.

19. Diagnostics/Service Mode: The iCOM control shall be provided with self diagnostics to aid in troubleshooting. The microcontroller board shall be

diagnosed and reported as pass/not pass. Control inputs shall be indicated as on or off at the front display. Control outputs shall be able to be turned on or off from the front display without using jumpers or a service terminal. Each control output shall be indicated by a LED on a circuit board.

20. Advanced Menus

    a. Factory Settings: Configuration settings shall be factory set based on the pre-defined component operation.
    b. Change Passwords: Menu shall allow new passwords to be set or changed.

E. iCOM Microprocessor Control with Large Graphic Display

1. The iCOM unit control with large graphic display shall include all of the features as listed above. In addition, it includes a larger graphical display and the additional features of:

    a. “System View”, Spare Parts List, Unit Diary
    b. The iCOM control processor shall be microprocessor based with a 320 x 240 dot matrix graphic front monitor display panel and control keys for user inputs mounted in an ergonomic, aesthetically pleasing housing.
    c. System View – Status Overview: “System View” shall display a summary of operation for the total number of operating units within a Unit to Unit (U2U) configuration.
    d. Spare Parts List: Menu shall include a list of critical spare parts, their quantity and part numbers.
    e. Unit Diary: Menu shall include a free field area within the unit memory where unit history may be stored for reference.
    f. Custom alarms are four (4) customer accessible alarm inputs to be indicated on the front panel. Custom alarms can be identified with prepared (programmed) labels for the following frequently used inputs:

        1) Leak Under Floor #1
        2) Leak Under Floor #2
        3) Main Fan Overload
        4) Open

2. Each alarm (unit and custom) can be separately enabled or disabled, selected to activate the common alarm, and programmed for a time delay of 0 to 255 seconds.

3. The audible alarm shall annunciate any alarm that is enabled by the operator.

4. A programmable common alarm shall be provided to interface user selected alarms with a remote alarm device.

5. All alarms shall be communicated to the EMS site monitoring system with the following information: date and time of occurrence, unit number and current temperature and humidity.

6. The Liebert iCOM control shall be compatible with Liebert remote monitoring and control devices.

7. The water circuit shall include a 2-way modulating valve. The Liebert iCOM positions the valve in response to room conditions.

1.2 SEQUENCE OF OPERATION – CRAC UNITS 1 & 2

A. CRAC Units 1 & 2 shall be started through the BMS. Under normal operation the two (2) CRAH units shall run continuously with the fans set at 50% of air delivery through the variable speed drive fan motors.

B. The Liebert iCOM Smart Aisle Control units take advantage of the variable fan speed and variable capacity and Chilled Water valve that are available on these units. This new control scheme uses this variable capacity technology and applies it to ensure that the inlet air temperature to the server is maintained while providing the greatest amount of energy savings. Maintaining the rack inlet air temperature ensures that the IT equipment operates trouble free and keeps the server fans from ramping up from their minimum speed.

C. Each Liebert cooling unit is equipped with an iCOM controller that has the ability to collect and control a supply (Discharge) air temperature sensor, a return temperature and humidity sensor and up to 20 rack temperature sensors. The Liebert iCOM Smart Aisle control utilizes each of these sensors to determine how to adjust the cooling, heating, humidification and dehumidification capacity of the unit.

D. Both Liebert iCOM floor mount cooling units have the ability to communicate with each other through standard Ethernet connectivity. This communication between the units allows for coordination of cooling capacity, zoned air flow distribution, fail over protection and different modes of standby operation. To reach the full benefit of the Liebert iCOM Smart Aisle Control, the units need to have this network connected.

E. Inlet Rack Temperature Control:

1. The Liebert iCOM Smart Aisle control monitors the inlet temperature to the racks using up to 20 rack temperature sensors that are connected to each iCOM control. These inlet rack temperature sensors are used to control the air flow (fan speed) and discharge air temperature simultaneously for each unit. The air flow is increased and the chilled water valve modulated open simultaneously when the Inlet rack sensors detect a temperature higher than the user entered setpoint and will decrease airflow when IT load decreases or changes to the application are modified (i.e. Containment).

   The cooling unit's fan speed is determined based on the amount of deviation from temperature setpoint (Proportional) and the length of time the actual temperature has deviated from temperature setpoint (Integral).

   The fan speed control takes into account the actual temperature as it compares to the temperature set point and will modify how fast the fans can change speed to avoid overshooting the set point.

In addition to the speed filters the fan speed also has pre-programmed independent acceleration and deceleration rates.

2. These control tuning parameters allow the fans and chilled water valve to speed up quickly to match rapid IT load changes and reacts to containment doors being opened and closed while still providing stable control when the application returns to steady state operation.

F. Supply Temperature Control:

1. The Liebert iCOM controller monitors and adjusts the supply (Discharge) air temperature of the unit to provide a consistent under floor air temperature by adjusting the Chill Water valve position. The supply temperature control operates the cooling capacity independently of the air flow that is controlled from the inlet rack temperature. The only time that the chill water valve will deviate from the supply temperature control is when temperature compensation has been activated. (See description below).

Additional details of Supply Operation:

2. The valve position is based on the amount of deviation from temperature setpoint (Proportional) and the length of time the actual temperature has deviated from temperature setpoint (Integral).

3. The valve also has pre-programmed independent filters that will slow the rate of change as the actual temperature approaches temperature setpoint.

G. Temperature Compensation:

1. Temperature compensation provides a useful link between the cold aisle temperature, cooling capacity and air flow. Temperature compensation allows for the units to automatically adjust the supply air temperature setpoint when the unit has reached its maximum airflow of 100% and the cold aisle temperature remains above the cold aisle setpoint. In this situation the temperature compensation feature will be enabled and the supply temperature setpoint will be decreased proportionally until the Inlet rack temperature reaches the setpoint. Changes that could invoke temperature compensation would be the removal of floor tiles in non cold aisle areas, incorrect supply temperature setpoint, unit failure in another zone or greater than expected heat load changes in IT equipment. As a further protection the temperature compensation routine also ties into the cascade / standby operation when Teamwork Mode 3 is selected.

H. Humidity Control:

1. The Liebert iCOM controller monitors the return dry bulb temperature and return relative humidity to calculate a dew point. This dew point is then used to activate dehumidification based on the user entered Setpoints. Using dew point as the internal control method rather than relative humidity prevents inadvertent activation of humidification and dehumidification based on temperature changes at the return air of the unit. With a focus on supply and cold aisle temperatures instead of return it is critical that the control makes humidification decisions

based on the actual room moisture content instead of the relative humidity measured in the return air which will fluctuate based on IT load.

2. iCOM allows for the operator to enter / view the humidity control points in either dew point temperature or relative humidity %. For those users who are not ready to convert to dew point values on the display, iCOM will still give the user the benefit of dew point control while still providing the ability to accept a relative humidity input. The iCOM control will take the temperature and relative humidity % to calculate the dew point for control purposes but will convert this data back to relative humidity % to show on the display.

I. Teamwork Mode 3 (Smart Team):

1. When the units are set to operate in Smart Aisle Control mode and have been connected in a unit to unit network, then Teamwork Mode 3 can be selected. Teamwork provides coordination between the units that will prevent “fighting” by not allowing units to operate in conflicting modes of operation at the same time by selecting which mode to operate within based on the average of the collective unit sensors (cooling versus heating, and humidifying versus dehumidifying).

2. Teamwork mode 3 allows the cooling capacity (Supply Air Sensor) to operate as a local control by removing only the amount of load required to maintain the discharge air temperature at each unit. This allows for unbalanced room load while maintaining a consistent discharge air temperature. The fan speed is controlled by the remote rack sensors of all units, providing a controlled delivery method of the air to the cold aisle. In raised floor applications, units will share sensor information to achieve even under floor air distribution. This distribution is achieved by operating all fans in parallel, which will also provide the user with the greatest energy efficiency.

J. Cascade:

1. When data center environments require the cooling equipment to modulate from very low loads to the full design load, iCOM can coordinate unit capacity and unit activation in accordance with the Teamwork Mode 3 operation described above. The iCOM smart aisle controlled units that are placed into Standby mode will activate as the room environment demands more cooling capacity. iCOM will monitor the rack sensors and current operating state of each unit to determine when to activate a standby unit.

2. To provide the most efficient operation from a system perspective, iCOM will first ramp the operating units fans and chilled water valve to compensate for the increased heat load. Once the operating units have reached a set fan speed, the supply compensation will be activated to determine if a lower supply temperature can compensate for the load increase. Once the supply compensation routine has reached its threshold then iCOM will activate a standby unit within the group.

K. Lead / Lag – Failure Scenarios

1. When redundancy configurations are required the iCOM unit-to-unit network has built in fail over conditions that require no building management interaction. The

first and probably most common failure scenario is a single unit or component failure. In this situation iCOM will automatically activate a standby unit in the place of the failed unit.

2. Unit-to-Unit and sensor failure scenarios have also been programmed into the iCOM controller. For example if the remote sensors fail at the unit level, the unit will continue to operate using the other unit's remote sensor values. If all remote sensors fail then the fan speed will begin to operate from the supply sensor. If the supply air sensor fails then the unit will default to 100% fan and cooling capacity. In the event of a unit to unit failure each unit will operate from its individual sensor network.

L. Application and Configuration of Rack Sensors

1. The Inlet rack temperature sensors should be placed on a rack that is within the area of influence of the connected cooling unit. The sensors and units are color matched to show the location of each unit's sensors. The sensors can be interlaced with one another to provide redundancy of the different unit's sensors. Remember that the sensor data from each unit is shared at the teamwork level so placement of the sensors is flexible with your specific application. So even when one unit fails the other units are still able to react based on the failed units sensors.

2. Each unit can connect up to 10 sensor modules with each module allowing for 2 temperature probes for a total of 20 temperature readings per cooling unit. Each of the 2 probes allows for 6 feet of distance between the temperature probe and the module. This provides the flexibility to either place both temperature sensor probes at the top of two different racks or to place one sensor probe in the middle of the rack and one at the upper two thirds of the rack. Sensors can be placed in other locations like the hot aisle but should be set as a reference sensor and not a controlling sensor. This will allow the sensor to be monitored by the iCOM display and building management system but will not affect unit operation.

3. The rack sensors that are set to control have the flexibility to be set in different averaging schemes. There are three different levels of sensor calculations; at the sensor level, at the unit level and at the system level (unit to unit network). At the sensor level, the two probes on each rack sensor can be set to average or take the maximum value of the two sensors. The setting at the unit level allows the operator to select how many of the controlling sensors are averaged. If the unit has 10 rack sensors connected for control, the operator can elect to average 1 through 10 of the sensors. For example selecting 3 sensors to average would use the 3 highest sensor readings out of the 10 possible sensors. Even though only 3 sensors are being used for the average all 10 are actually being dynamically monitored with iCOM's rack sensor scanning routine. This means that the 3 highest sensors today may not be the 3 highest sensors tomorrow.

4. The system level calculation provides the same level of flexibility as described above for the unit level sensor configuration. Providing this level of configuration at the unit and system level coupled with the rack sensor scanning allows the units and system to be setup for a variety of applications, including no containment, end containment and total containment. In addition it also allows

iCOM to adjust airflow and cooling capacity as the environment changes or if the IT load shifts, increases or decreases.

M. Backdraft Damper Operation by EC Fans

1. The Liebert iCOM controller has the ability to operate EC Fans at very low RPM's to effectively act as a backdraft damper. The power used to prevent air flow from entering a standby unit from the raised floor by spinning the fans at a low RPM is much less expensive than the additional static that conventional mechanical dampers introduce while the unit is in operation.

N. Rack Graph Screen

1. With the addition of the Inlet rack sensors and teamwork mode 3, iCOM can now show the sensor data on the main display. The system main screen provides a system view that provides a quick overview of all units within a specific zone. The system main screen will display the average, maximum and minimum Inlet rack sensor data to show the consistency of temperature throughout an area. It will also provide an average of the fan speed and cooling capacity which provides an estimate of the current operating unit's capacity. The unit main screen will provide a more detailed look at Inlet rack sensor temperatures. From a large iCOM display all units within the group can be viewed.

O. Monitoring Capability

1. All of the new smart aisle parameters like supply temperature, Inlet rack temperatures and dew point are all available through the BMS monitoring connection with the use of the new Intellislot cards.

    a. IS-IPBML (BACNet IP and Modbus IP (*provided on MCSO project*)
    b. IS-485L (Modbus 485 RTU)
    c. IS-WEBL (SMTP, SNMP, SMS and HTTP)

P. Event / Alarm Commissioning Assistant

1. One of the time-consuming activities during managed equipment commissioning and startup is to verify alarms and events are being transmitted from the unit level to the building management system. This commissioning phase verifies that all of the data points have been mapped correctly and will alert the facilities manager of a problem. To activate these alarms / events the management equipment would normally need to be manipulated by changing alarm thresholds to activate these alarms for verification. Liebert iCOM has now added a commissioning menu to trigger these alarms and events by selecting the event number that needs verification.

SECTION 23 82 19

FAN COIL UNITS

PART 1 GENERAL

1.1 SUMMARY

A. Provide a single point connection to the unit.

PART 2 DESIGN STANDARD

2.1 CABINET

A. Eighteen gauge galvanized steel with zinc coating. Entire casing including access panels shall be insulated with 1" thick, 1-1/2 lb./ft^3 foil-faced fiberglass insulation. Back panel shall have a 2" filter frame with filter access and be complete with duct collar. Access panels shall be removable for inspection and maintenance. Filter access shall be modified as required by actual installation to allow complete servicing and easy replacement.

2.2 FANS

A. Fans shall be DWDI, forward curved, centrifugal type, dynamically balanced and mounted on solid steel fan shaft. Fan bearings are permanently lubricated, resiliently mounted, self-aligning ball bearings.

2.3 COILS

A. Coils shall be of the extended surface plate fin and staggered tube type constructed of 1/2" O.D. seamless copper tubing and rippled aluminum fins. Coils shall be suitable for the application and have as a minimum the number of rows tabulated in the unit schedule.

2.4 DRAIN PAN

A. Drain pan shall be fabricated of stainless steel or plastic, insulated with closed cell insulation sealed with mastic and be pitched towards the drain connection. An auxiliary drain pan connection shall be provided.

2.5 MOTOR AND DRIVE (DIRECT)

A. Motor shall be high efficiency; permanently lubricated sleeve bearing with UL listed automatic reset thermal overload protection and three separate horsepower taps. Motor shall be minimum horsepower and electrical service as tabulated in the unit schedule. Unit shall be provided with motor starter or motor rated contactors and shall be U.L. listed.

2.6 MOTOR AND DRIVE (BELT)

A. Motor mount shall be a hinged type for simple belt tension adjustment and shall be securely fastened to unit frame. Drive shall be V-belt with a variable pitch motor sheave. Motor shall be minimum horsepower and electrical service as tabulated in the unit schedule. Unit shall be provided with motor starter or motor rated contactors and shall be U.L. listed.

2.7 DISPOSABLE FILTER

A. Provide two sets (for each unit) MERV 8, 2" deep pleated, disposable filter of medium efficiency in a standard commercial size. Filter shall be installed in a four-sided filter frame at the air inlet. Contractor shall remove one side in field to accommodate the direction for the most accessible filter pull. Piping and electrical connections shall be so located to eliminate any interference with removal and replacement of filter. The second set of filters is to be installed immediately prior to air balancing.

2.8 ELECTRIC RESISTANCE HEAT

A. The unit manufacturer shall furnish an electric resistance heating assembly where required in the contract documents, with the heating capacity, voltage and steps as shown in the schedule. The heater assembly shall be designed and rated for installation to the air handling unit in the blow-through configuration without the use of duct extensions or transitions between the unit and the heater assembly. The heater assembly shall be factory assembled to the air handling unit and completely factory wired. The heater/unit assembly shall be listed for zero clearance, meeting all NEC requirements, and be ETL/UL listed in compliance with UL/ANSI Std. 1995.

B. All heating elements shall be open coil type of 80/20 nichrome wire mounted in ceramic insulators and housed in an insulated heavy gauge galvanized steel housing. All elements shall terminate in a machine staked stainless steel terminal secured with stainless steel hardware. The element support brackets shall be spaced no greater than 3-1/2" on center. All internal wiring shall be rated for 105EC minimum.

C. All heaters shall include over-temperature protection.

D. An incoming line power distribution block shall be provided. The power distribution block shall be designed to accept incoming power wiring capable of carrying 125% of the calculated load current.

END OF SECTION

SECTION 23 88 10
DUCT LEAK TESTING

PART I - GENERAL

1.1 SCOPE OF WORK

Leak test *all ductwork from AHU's to Terminal Units* per SMACNA HVAC Air Duct Leakage Test Manual, latest Edn. Commissioning Agent and/or Engineer to attend test.

A. Furnish testing subcontractor's testing qualifications and equipment certifications prior to awarding contract. Testing subcontractor shall have completed testing on a minimum of five similar projects. Owner reserves the right to review and require updating or request alternate testing contractors should qualifications or equipment be found insufficient in the owner's sole discretion.

B. Submit the Air Duct Leakage Test Plan including project specific procedures, forms, and drawings to be used. Plan and procedures shall be performed per SMACNA HVAC Air Duct Leakage Test Manual standard protocols.

C. Submit the Preliminary Leak Test Field Report to the Commissioning Agent and Engineer for review and approval prior to the Final Report.

D. Include re-testing for any portions of duct found not to meet leakage requirements. All ductwork system shall be completed within allowable leakage rates for each pressure and seal classification per IECC and SMACNA.

1.2 WORK INCLUDED, BUT NOT INCLUSIVE

1.2.1 Provide all labor, materials, and equipment necessary to leak test all ductwork per SMACNA HVAC Air Duct Leakage Test Manual, latest Edn.

Pressure Class	System	Seal Class Required
4" (medium)	Ducts from AH to each TU inlet	A
2" (medium)	Ducts from TU to devices, relief, exhaust ducts	A

1.2.2 Allowable Leakage: Maximum of leakage allowed per the more stringent of either IECC or SMACNA latest edition requirements. If the Total Leakage exceeds either of these standards the construction shall be inspected, tested with test smoke, causes repaired or corrected, and the system retested until the tested leakage rate is below this acceptable limit.

1.3 INTENT

1.4.1 These specifications and the specifications on plans are intended to provide for a complete and thorough leak test and proof of proper duct installation of mechanical ductwork.

PART II - EXECUTION

2.0 COORDINATION

2.1 Coordination with mechanical contractor, engineer, construction project manager, and commissioning agent is required.

3.0 CLEAN-UP

Upon completion of the work of this section plug any and all duct holes created for testing. Clean and remove any tubing, tape, or similar detritus from the job site.

(END OF SECTION)

SECTION 23 88 11
UNDERFLOOR AREA LEAK TESTING

I. Scope of Work and Definitions.

This Scope of Work (SOW) is for air leakage testing of the Underfloor Air Distribution (UFAD) plenums.

The air leakage sources are joints between the slabs and: partitions; shafts; and electrical, plumbing, and duct penetrations in the raised access floor. Other air leakage sources include floor panel seams and edge closures; electrical power connection and outlet devices; communications and data cable outlet devices; air diffuser devices that do not close tightly; and other openings including ducts, piping, electrical conduits, etc.

Category 1 leaks (i.e., General Construction Leaks) are leaks of cool conditioned supply air from the underfloor plenum into other building cavities thence either from the building or into return air passages back to the air handling units or building exhaust air system. Such leaks have several negative impacts upon the system performance, the most immediate of which is that, if the leakage rate is severe enough, there may not be enough air left to adequately cool the space under high load conditions. Under that condition or conditions of even less such leakage, where the space load can still be handled, such leaks cause an energy burden.

Category 2 leaks (i.e., Product Leaks) are those that leak air through raised floor system components into the space to be conditioned. The components through which such leaks occur include: Floor panel seams and edge closures; Electric power connection and outlet devices; Communications & data cable outlet devices; Air diffuser devices that do not close tightly.

II. UFAD Air Leakage Testing Procedures.

A. The permanent building underfloor air distribution plenums shall then be tested by the following procedures. These test results shall be professionally certified by a nationally recognized Testing, Adjusting, and Balancing Contractor or agency. Documentation of the testing shall be provided in a written report.

B. The testing shall be performed after the concrete surfaces of the plenum have been sealed, and all mechanical and electrical devices, equipment, cables, racks, diffusers, power connectors and voice/data connectors and floor finishes have been installed.

C. The testing shall be witnessed by the Design Engineer, Commissioning Authority and the Owner or Owner's Representatives.

1. An independent test fan shall be provided which shall have the capability of supplying various airflow quantities from shutoff to 120% of design airflow quantity required for the zone being tested and shall be driven by a variable speed inverter. The test fan(s) shall be installed with a calibrated airflow measuring station and the supply duct connected into the plenum with an adhesive sealed pressure tight connection. Note: Scaling of Fan Volume is not permitted.

2. A static pressure sensor-controller shall be inserted into the plenum and calibrated against a calibrated static pressure sensor immediately adjoining it. The controller shall be arranged to control the speed of the test fan.

3. The UFAD plenum shall be installed complete with the supply diffusers, electrical power outlets, and voice/data outlets. The supply diffusers, whether automatically or manually controlled, shall be in the fully closed design position.

4. The fan shall be operated to hold the test static pressure in the plenum at 0.08 in w.g.

5. The system shall be operated for a sufficient time to establish a steady-state static pressure within the zone being tested. Steady-state shall be defined by at least six contiguous sets of readings of plenum static pressures that do not vary by more than + 0.005 in. wg. (1.2 Pa).

6. After steady-state has been established, the measured static pressure (in. wg. or Pa) and airflow rate (CFM or l/s) shall be recorded for six consecutive times at uniform intervals. This average value of the airflow rate will be considered the sum of the Category 1 and Category 2 leakage (Total Leakage).

7. If the Total Leakage exceeds 670 cfm (equivalent to 0.1 cfm/sf), the construction shall be inspected, tested with test smoke, causes repaired or corrected, and the system retested until the tested leakage rate is below this acceptable limit.

    a. If the tested air leakage is above acceptable limit, a smoke test shall be conducted by injecting a non-toxic “theatrical” smoke into the test fan intake and observing the pathways of the smoke emitted from the floor plenum being tested. The purpose of this test is to provide visualization of the sources and pathways of air leakage for the information of the design and construction team.

SECTION 23 88 11
UNDERFLOOR AREA LEAK TESTING

I. Scope of Work and Definitions.

This Scope of Work (SOW) is for air leakage testing of the Underfloor Air Distribution (UFAD) plenums.

The air leakage sources are joints between the slabs and: partitions; shafts; and electrical, plumbing, and duct penetrations in the raised access floor. Other air leakage sources include floor panel seams and edge closures; electrical power connection and outlet devices; communications and data cable outlet devices; air diffuser devices that do not close tightly; and other openings including ducts, piping, electrical conduits, etc.

Category 1 leaks (i.e., General Construction Leaks) are leaks of cool conditioned supply air from the underfloor plenum into other building cavities thence either from the building or into return air passages back to the air handling units or building exhaust air system. Such leaks have several negative impacts upon the system performance, the most immediate of which is that, if the leakage rate is severe enough, there may not be enough air left to adequately cool the space under high load conditions. Under that condition or conditions of even less such leakage, where the space load can still be handled, such leaks cause an energy burden.

Category 2 leaks (i.e., Product Leaks) are those that leak air through raised floor system components into the space to be conditioned. The components through which such leaks occur include: Floor panel seams and edge closures; Electric power connection and outlet devices; Communications & data cable outlet devices; Air diffuser devices that do not close tightly.

II. UFAD Air Leakage Testing Procedures.

A. The permanent building underfloor air distribution plenums shall then be tested by the following procedures. These test results shall be professionally certified by a nationally recognized Testing, Adjusting, and Balancing Contractor or agency. Documentation of the testing shall be provided in a written report.

B. The testing shall be performed after the concrete surfaces of the plenum have been sealed, and all mechanical and electrical devices, equipment, cables, racks, diffusers, power connectors and voice/data connectors and floor finishes have been installed.

C. The testing shall be witnessed by the Design Engineer, Commissioning Authority and the Owner or Owner's Representatives.

1. An independent test fan shall be provided which shall have the capability of supplying various airflow quantities from shutoff to 120% of design airflow quantity required for the zone being tested and shall be driven by a variable speed inverter. The test fan(s) shall be installed with a calibrated airflow measuring station and the supply duct connected into the plenum with an adhesive sealed pressure tight connection. Note: Scaling of Fan Volume is not permitted.

2. A static pressure sensor-controller shall be inserted into the plenum and calibrated against a calibrated static pressure sensor immediately adjoining it. The controller shall be arranged to control the speed of the test fan.

3. The UFAD plenum shall be installed complete with the supply diffusers, electrical power outlets, and voice/data outlets. The supply diffusers, whether automatically or manually controlled, shall be in the fully closed design position.

4. The fan shall be operated to hold the test static pressure in the plenum at 0.08 in w.g.

5. The system shall be operated for a sufficient time to establish a steady-state static pressure within the zone being tested. Steady-state shall be defined by at least six contiguous sets of readings of plenum static pressures that do not vary by more than + 0.005 in. wg. (1.2 Pa).

6. After steady-state has been established, the measured static pressure (in. wg. or Pa) and airflow rate (CFM or l/s) shall be recorded for six consecutive times at uniform intervals. This average value of the airflow rate will be considered the sum of the Category 1 and Category 2 leakage (Total Leakage).

7. If the Total Leakage exceeds 670 cfm (equivalent to 0.1 cfm/sf), the construction shall be inspected, tested with test smoke, causes repaired or corrected, and the system retested until the tested leakage rate is below this acceptable limit.

    a. If the tested air leakage is above acceptable limit, a smoke test shall be conducted by injecting a non-toxic “theatrical” smoke into the test fan intake and observing the pathways of the smoke emitted from the floor plenum being tested. The purpose of this test is to provide visualization of the sources and pathways of air leakage for the information of the design and construction team.

SECTION 23 88 12
MECHANICAL WATER SYSTEM TREATMENT

PART I - GENERAL

1.1 SCOPE OF WORK

1.1.1 Furnish all labor and materials to properly service the mechanical water (Hydronic) systems in the building including chilled water systems.

1.1.2 Furnish chemical supplies for the duration of the warrantee period, one chemical storage tank for each system, dispensing devices for each system including automated dispenser controllers, tubing, pot feeders, test ports, and any miscellaneous equipment and labor.

1.1.3 All service work and final chilled water quality requirements will be in conformance with the water quality and maintenance requirements of the more stringent of the final selected air handler unit manufacturer or the Chiller manufacturer requirements.

1.1.4 Submit water treatment subcontractor's qualifications and equipment certifications prior to awarding contract. Owner reserves the right to review and require updating or request alternate contractors should qualifications or equipment be found insufficient in the owner's sole discretion.

1.1.5 Submit a water flush and treatment plan including project specific procedures, forms, chemicals to be used, and water quality standards to be achieved. Flush and treatment plan and procedures shall be performed per industry standard protocols. Include copies of manufacturer's water quality requirements for the boiler, heat exchanger, and air handler manufacturers to demonstrate compliance goals.

1.1.6 Provide final flush and water treatment test reports to engineer and commissioning agent demonstrating the water systems have been flushed and treated to within manufacturer's acceptable requirements.

1.2 WORK INCLUDED, BUT NOT INCLUSIVE

1.2.2. Hydronic System Service:

Flush Hydronic system out completely, remove and dispose off site all contaminated water, flush all system strainers and filters the building, charge system with new chemical water treatment to within cooling tower/boiler manufacturer's recommended water quality standards including: ph, conductivity, calcium, bacteria, total chlorine, chlorides, organic phosphorous, and alkalinity.
Include a total of quarterly follow-up water treatments at 3 months intervals following substantial completion to maintain proper water treatment levels for the entire warrantee period. Furnish a complete report following each service.

1.2.3 Chemical Treatment Equipment

Verify proper function of all chemical feeders, timers, tanks, tubing and treatment hardware. Provide written report on any deficient of failed water treatment hardware for replacement or repair.

1.2.4 Follow Up Services:

Include all chemicals to maintain water treatment within previously stated manufacturer's standards for the entire warrantee period.

1.2.5 Reporting:

Provide written water service reports on each water system documenting the water treatment has been adequate to keep the water system within manufacturer guidelines for the entire warrantee period. Identify each report by system and date.

1.3 INTENT

1.4.1 These specifications and the specifications on plans are intended to provide for a complete and thorough service of specified mechanical Hydronic systems on the project.

PART II - EXECUTION

2.0 COORDINATION AND INSTALLATION

2.1 Provide field trips to provide quarterly warrantee treatments.
2.3 Provide a list of recommended corrective repairs for any water system equipment found to be defective or requiring more than service per the referenced Standards during the entire warrantee period.

3.0 CLEAN-UP

Upon completion of the work of this section, remove from the premises all waste, debris collected from strainers, and any debris relating to the conduct of this portion of the work.

(END OF SECTION)

SECTION 26 05 10

GENERAL PROVISIONS

PART 1 GENERAL

1.1 SUMMARY

A. This section of the specifications outlines the provisions of the contract work to be performed under this Division. Work includes but is not limited to site electrical, building power distribution, lighting, and life safety systems for the 911 facility to be constructed. The facility electrical systems shall be installed in accordance with NEC Art. 708 and all raceways, wiring, and wiring methods shall comply with the respective requirements. Drawings and general provisions of the Contract, including General Requirements Division 01 Specification Sections, apply to this section. This section applies to and forms a part of each section of the specifications in Divisions 26 & 28.

B. The drawings and specifications do not specify exact installation means and methods or Contractor safety procedures. Installation means and methods and safety procedures are, and shall remain, the responsibility of the Contractor. No instruction or statement made on the drawings, specifications, future addenda, or change orders shall be interpreted to shift this responsibility away from the Contractor.

C. These specifications contain statements which are more definitive or more restrictive than those contained in the General Conditions. Where these statements occur, they shall take precedence over the General Conditions. Where the word "provide" or "provision" is used, it shall be definitely interpreted as "furnishing and installing complete in operating condition." Where the words "as indicated" or "as shown" are used, they shall mean “as shown on contract drawings." Where items are specified in the singular, this Division shall provide the quantity as shown on the drawings, plus any spares or extras mentioned on drawings or in specifications. All specified and supplied equipment shall be new.

1.2 CODES, PERMITS AND FEES

A. Comply with all applicable laws, ordinances, rules, regulations, codes or rulings of governmental units having jurisdiction, as well as standards of the National Fire Protection Association and serving utility requirements.

B. Obtain and pay for permits, fees, inspections, meters, utility connections and extensions and the like associated with work in each section of this Division.

C. Installation procedures, methods, and conditions shall comply with the latest requirements of the Federal Occupational Safety and Health Act (OSHA).

1.3 STANDARDS

A. The following standard publications of the latest editions and supplements thereto shall form a part of these specifications. All electrical work shall, at a minimum, be in accordance with the applicable sections of these standards.

National Fire Protection Association Standards (NFPA).

Underwriters' Laboratories, Inc. (UL).

Certified Ballast Manufacturers Association (CBM).

National Electrical Manufacturers Association (NEMA).

Institute of Electrical and Electronic Engineers (IEEE).

American Society for Testing and Materials (ASTM).

National Board of Fire Underwriters (NBFU).

National Board of Standards (NBS).

American National Standards Institute (ANSI).

National Electrical Testing Association (NETA).

Insulated Power Cable Engineers Association (IPCEA).

Electrical Testing Laboratories (ETL).

Local Building Codes.

1.4 WORK AND MATERIALS

A. All electrical materials and equipment shall be new and of the type and quality specified, and shall be listed by UL and bear their label where standards have been established, in compliance with the applicable standards of NEC (NFPA 70), NFPA, ANSI, IEEE, IPCEA and NEMA. Replace or repair any nonconforming, damaged, or defective items at no extra cost to the Owner.

B. All equipment, fixtures, devices, materials shall be new and ul listed.

C. Acceptable manufacturers for electrical equipment (gear, panels, transformers, breakers, disconnects, controllers) include: Square D, Cutler-Hammer, GE, Siemens.

D. Submittal of shop drawings, product data, and samples will be accepted only when submitted by the contractor to the designated person by the owner. Data submitted from subcontractors and material suppliers directly to the architect/engineer will not be processed.

E. Mark drawings to indicate revisions to equipment, raceway, and device locations and revisions to panel schedules.

F. Contractor shall make tests at his own expense, in the presence of the owner or his represented, as required by owner and/or any inspection department. Tests shall be made to ascertain whether the system and equipment installed comply with the drawings and specifications.

G. Coordinate electrical equipment and materials installation with other building components. Verify all dimensions by field measurements. Arrange for chases, slots, and openings in other building components to allow for electrical installations.

H. Coordinate the installation of required supporting devices and sleeves to be set in poured in place concrete and other structural components, as they are constructed.

I. Sequence, coordinate, & integrate installations of electrical materials and equipment, giving particular attention to large equipment requiring positioning prior to closing-in building areas.

J. Coordinate the installation of electrical materials and equipment above ceilings with suspension system, mechanical equipment and systems, & structural components.

K. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage. The equipment shall be kept under controlled conditions to prevent moisture and/or condensation on critical electrical parts.

END OF SECTION

SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Alcan Products Corporation; Alcan Cable Division.
2. Alpha Wire.
3. Belden Inc.
4. Encore Wire Corporation.
5. General Cable Technologies Corporation.
6. Southwire Incorporated.

C. Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.

D. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN-2-THWN-2, Type XHHW-2, Type UF, Type USE, and Type SO.

E. Multiconductor Cable: Comply with NEMA WC 70/ICEA S-95-658 for armored cable, Type AC, metal-clad cable, Type MC, mineral-insulated, metal-sheathed cable, Type MI, Type SO and Type USE with ground wire.

F. Non-metallic, residential wire (such as Romex) are not acceptable.

G. Mineral insulated cable shall be AmerCable, M.I. Cable Company (MICC), or as accepted.

H. Armor-clad (AC) cable shall not be permitted to be used in this project.

2.2 CONNECTORS AND SPLICES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. AFC Cable Systems, Inc.
2. Gardner Bender.
3. Hubbell Power Systems, Inc.
4. Ideal Industries, Inc.
5. Ilsco; a branch of Bardes Corporation.
6. NSi Industries LLC.
7. O-Z/Gedney; a brand of the EGS Electrical Group.
8. 3M; Electrical Markets Division.
9. Tyco Electronics.

C. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper for feeders rated smaller than 100A; copper for feeders rated 100A and larger, aluminum for feeders 100A and larger only where indicated on plans (to be quoted as a deduct alternate to copper equivalent). Solid for No. 14 AWG and smaller; stranded for No. 12 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 14 AWG and smaller; stranded for No. 12 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type XHHW-2, single conductors in raceway.

B. Exposed Feeders: Type XHHW-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type XHHW-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.

E. Feeders Installed below Raised Flooring: Type THHN-2-THWN-2, single conductors in raceway.

F. Feeders in Cable Tray: Type XHHW-2, single conductors larger than No. 1/0 AWG.

G. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-2-THWN-2, single conductors in raceway for #6 and smaller, type XHHW-2 for sizes #4 and larger.

H. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-2-THWN-2, single conductors in raceway for #6 and smaller, type XHHW-2 for sizes #4 and larger.

I. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-2-THWN-2, single conductors in raceway for #6 and smaller, type XHHW-2 for sizes #4 and larger.

J. Branch Circuits Installed below Raised Flooring: Type THHN-2-THWN-2, single conductors in raceway for #6 and smaller, type XHHW-2 for sizes #4 and larger.

K. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 26 05 33 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

Wire Pulling Lubricant: Richards "Gel Lube 7/5"; American Polywater A, C, G&J; Quelcor "Quelube"; American Colloid "Slip X-300"; Thomas/Jet Line "Slipry Loob"; Ideal "Wire Lube"; Mac "Wirepull"; Minerallac "Wire-Wax"; or Electro "Y-er Eas."

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 26 05 29 "Hangers and Supports for Electrical Systems."

G. Complete cable tray systems installation according to Section 26 05 36 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

3.4 CONNECTIONS

A. 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-486B. Record values in the field.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 **inches** of slack. Install conductors at each junction box designated for future connection with at least 12” of slack.

D. Terminations at Circuit Breakers and Switches:

1. #10 and #8 AWG wire, locking tongue lug, Buchanan "Termend," or as accepted.
2. #6 AWG and larger wire, round flange solderless lug, Burndy "Quick-Lug" type QDA, or as accepted.

E. Fixture Connections: Pressure-type solderless connectors, Buchanan, Scotchlok, Wing Nut, or accepted equal.

F. Motor Connections: Solderless lug with RayChem GelCap, or as accepted.

G. Wire Splices:

1. Joints in Wire: #8 AWG and smaller wire, pressure-type solderless connectors, Buchanan, Scotchlok, Wing Nut, or as accepted. #6 AWG and larger wire, irreversible compression type, Burndy, Ilsco, or as accepted.

2. Wire Taps: Solderless lug, solderless compression lug, each with Raychem Gtap, Ilsco GTA, or GTT with insulating cover, or as accepted.
3. Exterior Below Grade Joints in Wire: Solderless lug, solderless compression lug, each with Raychem GelCap or as accepted.

H. Applied Insulation: Insulating materials shall be listed for the application. Voltage rating shall be equal to or greater than the factory-applied wire insulation. Raychem, 3M, Ilsco, or as accepted.

3.5 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 26 05 53 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

C. Markers and Tags: Plastic Wire Markers: T&B or Brady.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 05 44 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 07 84 00 "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors and conductors feeding the following critical equipment and services for compliance with requirements. Test duration shall be one minute minimum or as required by AHJ. Minimum resistance shall not be less than 50 megaohms.

    a. All emergency feeders.

    b. All normal powered feeders rated 100A and larger.

    c. 10% of branch circuits and feeders rated 60 – 100A.

2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

    a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
    b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

D. Test and Inspection Reports: Prepare a written report to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

E. Cables will be considered defective if they do not pass tests and inspections.

END OF SECTION

SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes grounding and bonding systems and equipment.

B. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Ground bonding common (with lightning protection system as applicable).
3. Copper building ground.
4. Foundation steel electrodes.
5. Lightning Protection System (as applicable)

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.4 INFORMATIONAL SUBMITTALS

A. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:

1. Test wells.
2. Ground rods.
3. Ground rings.
4. Ground bus bars.
5. Grounding arrangements and connections for separately derived systems.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

    a. Instructions for periodic testing and inspection of grounding features at test wells ground rings based on NETA MTS.

        1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
        2) Include recommended testing intervals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Burndy; Part of Hubbell Electrical Systems.
2. Dossert; AFL Telecommunications LLC.
3. ERICO International Corporation.
4. Fushi Copperweld Inc.
5. Galvan Industries, Inc.; Electrical Products Division, LLC.
6. Harger Lightning and Grounding.
7. ILSCO.
8. O-Z/Gedney; A Brand of the EGS Electrical Group.
9. Robbins Lightning, Inc.
10. Siemens Power Transmission & Distribution, Inc.

2.2 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.3 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches (24" U.N.O.) in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless irreversible compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.5 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 5/8 by 96 inches.

B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.

1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches long.
2. Backfill Material: Electrode manufacturer's recommended material.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, #4/0 AWG minimum.

1. Bury at least 24 inches below grade.
2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper

conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.5 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.
8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
9. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway

fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

G. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

H. Metallic Fences: Comply with requirements of IEEE C2.

1. Grounding Conductor: Bare copper, not less than No. 8 AWG.
2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.6 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 26 05 43 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.

1. Test Wells: Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building.

1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
2. Bury ground ring not less than 24 inches from building's foundation.

J. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.

1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

K. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 feet long. If reinforcing is in multiple pieces, connect together by the usual steel tie wires or exothermic welding to create the required length.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

E. Grounding system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).
5. Substations and Pad-Mounted Equipment: 5 ohms.
6. Manhole Grounds: 10 ohms.

H. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 ACTION SUBMITTALS

A. Product Data: For the following:

1. Steel slotted support systems.
2. Nonmetallic slotted support systems.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:

1. Trapeze hangers. Include Product Data for components.
2. Steel slotted channel systems. Include Product Data for components.
3. Nonmetallic slotted channel systems. Include Product Data for components.
4. Equipment supports.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Comply with NFPA 70.

1.8 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified together with concrete Specifications.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.; a division of Cooper Industries.
c. ERICO International Corporation.
d. GS Metals Corp.
e. Thomas & Betts Corporation.
f. Unistrut; Tyco International, Ltd.
g. Wesanco, Inc.

3. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

4. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
5. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
6. Channel Dimensions: Selected for applicable load criteria.

B. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch- diameter holes at a maximum of 8 inches o.c., in at least 1 surface.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Allied Tube & Conduit.
    b. Cooper B-Line, Inc.; a division of Cooper Industries.
    c. Fabco Plastics Wholesale Limited.
    d. Seasafe, Inc.

3. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
4. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
5. Rated Strength: Selected to suit applicable load criteria.

C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

D. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

    a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

        1) Hilti Inc.
        2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.

3) MKT Fastening, LLC.
4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Cooper B-Line, Inc.; a division of Cooper Industries.
2) Empire Tool and Manufacturing Co., Inc.
3) Hilti Inc.
4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 05 50 00 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 05 50 00 "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 03 30 00 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 26 05 33

RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets. **(Including floor boxes for concrete and raised floor installations)**
7. Handholes and boxes for exterior underground cabling.

B. Related Requirements:

1. Section 26 05 43 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

1.3 DEFINITIONS

A. ARC: Aluminum rigid conduit.

B. GRC: Galvanized rigid steel conduit.

C. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Seismic Qualification Certificates: For enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.

C. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AFC Cable Systems, Inc.
2. Allied Tube & Conduit.
3. Anamet Electrical, Inc.
4. Electri-Flex Company.
5. O-Z/Gedney.
6. Picoma Industries.
7. Republic Conduit.
8. Robroy Industries.
9. Southwire Company.
10. Thomas & Betts Corporation.
11. Western Tube and Conduit Corporation.
12. Wheatland Tube Company.

B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. ARC: Comply with ANSI C80.5 and UL 6A.

E. IMC: Comply with ANSI C80.6 and UL 1242.

F. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch, minimum.

G. EMT: Comply with ANSI C80.3 and UL 797.

H. FMC: Comply with UL 1; zinc-coated steel or aluminum.

I. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

J. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
2. Fittings for EMT:

   a. Material: Steel or die cast.
   b. Type: compression.

3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

K. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. AFC Cable Systems, Inc.
2. Anamet Electrical, Inc.
3. Arnco Corporation.
4. CANTEX Inc.
5. CertainTeed Corporation.
6. Condux International, Inc.

7. Electri-Flex Company.

8. Kraloy.

9. Lamson & Sessions; Carlon Electrical Products.

10. Niedax-Kleinhuis USA, Inc.

11. RACO; Hubbell.

12. Thomas & Betts Corporation.

B. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ENT: Comply with NEMA TC 13 and UL 1653.

D. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

E. LFNC: Comply with UL 1660.

F. Rigid HDPE: Comply with UL 651A.

G. Continuous HDPE: Comply with UL 651B.

H. Coilable HDPE: Preassembled with conductors or cables, and complying with ASTM D 3485.

I. RTRC: Comply with UL 1684A and NEMA TC 14.

J. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

K. Fittings for LFNC: Comply with UL 514B.

L. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

M. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Cooper B-Line, Inc.

2. Hoffman.

3. Mono-Systems, Inc.

4. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Hinged type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.4 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Allied Moulded Products, Inc.

2. Hoffman.

3. Lamson & Sessions; Carlon Electrical Products.

4. Niedax-Kleinhuis USA, Inc.

B. Listing and Labeling: Nonmetallic wireways and auxiliary gutters shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Description: Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover shall be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections shall be flanged and have stainless-steel screws and oil-resistant gaskets.

D. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.

E. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.

F. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

G. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.5 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Mono-Systems, Inc.

b. Panduit Corp.

c. Wiremold / Legrand, G3000 Series

C. Surface Nonmetallic Raceways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors. Product shall comply with UL 94 V-0 requirements for self-extinguishing characteristics.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Hubbell Incorporated.

b. Mono-Systems, Inc.

c. Panduit Corp.

d. Wiremold / Legrand, G3000 Series

D. Tele-Power Poles:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Mono-Systems, Inc.

b. Panduit Corp.

c. Wiremold / Legrand.

2. Material: Aluminum with clear anodized finish.
3. Fittings and Accessories: Dividers, end caps, covers, cutouts, wiring harnesses, devices, mounting materials, and other fittings shall match and mate with tele-power pole as required for complete system.

2.6 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Adalet.
2. Cooper Technologies Company; Cooper Crouse-Hinds.
3. EGS/Appleton Electric.
4. Erickson Electrical Equipment Company.
5. FSR Inc.
6. Hoffman.
7. Hubbell Incorporated.
8. Kraloy.
9. Milbank Manufacturing Co.
10. Mono-Systems, Inc.
11. O-Z/Gedney.
12. RACO; Hubbell.
13. Robroy Industries.
14. Spring City Electrical Manufacturing Company.
15. Stahlin Non-Metallic Enclosures.
16. Thomas & Betts Corporation.
17. Wiremold / Legrand.
18. Panduit.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

F. Metal Floor Boxes:

1. Material: Cast metal or sheet metal.
2. Type: Fully adjustable.
3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Floor boxes for installation in raised floors, suitable for plenum use, with power and data terminations, Panduit Panzone.

H. Nonmetallic Floor Boxes: Nonadjustable, rectangular.

1. Listing and Labeling: Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

I. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

J. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb.

1. Listing and Labeling: Paddle fan outlet boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

K. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

L. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.

M. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

N. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

O. Gangable boxes are prohibited.

P. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 12 with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures: Fiberglass.
3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

Q. Cabinets:

1. NEMA 250, Type 12 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.7 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Armorcast Products Company.

    b. Carson Industries LLC.

    c. NewBasis.

    d. Oldcastle Precast, Inc.

    e. Quazite: Hubbell Power System, Inc.

    f. Synertech Moulded Products.

3. Standard: Comply with SCTE 77.
4. Configuration: Designed for flush burial with closed bottom unless otherwise indicated.
5. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
6. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
7. Cover Legend: Molded lettering, "ELECTRIC.".
8. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
9. Handholes 12 Inches Wide by 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

C. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of polymer concrete.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Armorcast Products Company.

    b. Carson Industries LLC.

    c. NewBasis.

    d. Nordic Fiberglass, Inc.

    e. Oldcastle Precast, Inc; Christy Concrete Products.

f. Quazite: Hubbell Power System, Inc; Hubbell Power Systems.

g. Synertech Moulded Products.

3. Standard: Comply with SCTE 77.
4. Color of Frame and Cover: Gray.
5. Configuration: Designed for flush burial with closed bottom unless otherwise indicated.
6. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
7. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
8. Cover Legend: Molded lettering, "ELECTRIC.".
9. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
10. Handholes 12 Inches Wide by 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.8 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit (Damp, Dry or Concealed Locations): Electrical Metallic Tubing (EMT), compression fittings.
2. Exposed Conduit (Wet Locations): Electrical Metallic Tubing (EMT), listed weatherproof compression fittings.
3. Exposed Conduit (Where Subject to Physical Damage): Galvanized Rigid Conduit (GRC), Intermediate Metal Conduit (IMC).
4. Underground Conduit: Rigid Nonmetallic Conduit (RNC), Minimum Schedule 40. Encased in concrete.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): Liquid-Tight Flex Metal Conduit (LFMC) 18” Maximum.
6. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed or concealed, COPS feeder: GRC, IMC, 1 hour fire rated.

2. Exposed, COPS branch circuit: GRC, IMC, 1 hour fire rated (when outside of DCOA boundary). Within DCOA, IMC, EMT.

3. Exposed or concealed, COPS HVAC, Fire Alarm, Security, Emergency Communications, and Signaling Systems: GRC, IMC, 2 hour fire rated.

4. Exposed (Not Subject to Physical Damage): EMT.
5. Exposed (Where Subject to Physical Damage: Galvanized Rigid Conduit (GRC), Intermediate Metallic Conduit (IMC).
6. Concealed in Ceilings and Interior Walls and Partitions: Electrical Metallic Tubing (EMT).
7. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): Liquid-Tight Flex Metal Conduit (LFMC) in damp or wet locations.
8. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 nonmetallic in damp or wet locations. 4" Square x 2-1/8" Deep Boxes.

C. Minimum Raceway Size: 3/4-inch trade size. 1" minimum conduit size under-ground.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use compression, cast-metal fittings. Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

G. Install surface raceways only where indicated on Drawings.

H. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for hangers and supports.

E. Arrange stub-ups so curved portions of bends are not visible above finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.

G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

H. Support conduit within 12 inches of enclosures to which attached.

I. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-footintervals.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Arrange raceways to keep a minimum of 2 inches of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.

J. Stub-ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

K. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

L. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

M. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

N. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

O. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

P. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

Q. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

R. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

S. Surface Raceways:

1. Install surface raceway with a minimum 2-inchradius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

T. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

U. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Where otherwise required by NFPA 70.

V. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

W. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

X. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.

2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

Y. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

Z. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

AA. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

BB. Locate boxes so that cover or plate will not span different building finishes.

CC. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

DD. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

EE. Set metal floor boxes level and flush with finished floor surface.

FF. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Earth Moving section for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Earth Moving section
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Earth Moving section.
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.
    b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

6. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits but a minimum of 6 inches below grade. Align planks along centerline of conduit.
7. Underground Warning Tape: Comply with requirements in Section 26 05 53 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

D. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.

E. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 05 44 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Penetration Firestopping section.

3.7 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

SECTION 26 05 36

CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Ladder cable trays.
2. Single-rail cable trays.
3. Trough cable trays.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include data indicating dimensions and finishes for each type of cable tray indicated.

B. Shop Drawings: For each type of cable tray.

1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.

C. Delegated-Design Submittal: For seismic restraints.

1. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
2. Design Calculations: Calculate requirements for selecting seismic restraints.
3. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:.

1. Include scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements.
2. Vertical and horizontal offsets and transitions.
3. Clearances for access above and to side of cable trays.

4. Vertical elevation of cable trays above the floor or below bottom of ceiling structure.

B. Seismic Qualification Certificates: For cable trays, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR CABLE TRAYS

A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.

1. Source Limitations: Obtain cable trays and components from single manufacturer.

B. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.

C. Structural Performance: See articles on individual cable tray types for specific values for the following parameters:

1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
2. Concentrated Load: A load applied at midpoint of span and centerline of tray.
3. Load and Safety Factors: Applicable to both side rails and rung capacities.

2.2 LADDER CABLE TRAYS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Cooper B-Line, Inc.
2. Walker
3. P-W Industries

C. Description:

1. Configuration: Two I-beam side rails with transverse rungs welded to side rails.
2. Rung Spacing: 6 inches o.c.
3. Radius-Fitting Rung Spacing: 9 inches at center of tray's width.
4. Minimum Cable-Bearing Surface for Rungs: 7/8-inch width with radius edges.
5. No portion of the rungs shall protrude below the bottom plane of side rails.

6. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a200-lb concentrated load, when tested according to NEMA VE 1.
7. Minimum Usable Load Depth: 4 inches.
8. Straight Section Lengths: 10 feet except where shorter lengths are required to facilitate tray assembly.
9. Width: 18 inches unless otherwise indicated on Drawings.
10. Fitting Minimum Radius: 36 inches.
11. Class Designation: Comply with NEMA VE 1, Class 12B.
12. Splicing Assemblies: Bolted type using serrated flange locknuts.
13. Hardware and Fasteners: Steel, zinc plated according to ASTM B 633.
14. Splice Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

2.3 SINGLE-RAIL CABLE TRAYS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Cooper B-Line, Inc.
2. Walker
3. P-W Industries

C. Description:

1. Configuration: Center rail with extruded-aluminum rungs arranged symmetrically about the center rail.
2. Construction: Aluminum rungs mechanically connected to aluminum center rail in at least two places, with ends finished to protect installers and cables.
3. Rung Spacing: 6 inches o.c.
4. Radius-Fitting Rung Spacing: 9 inches at center of tray's width.
5. Straight Section Lengths: 10 feet except where shorter lengths are required to facilitate tray assembly.
6. Width: 18 inches unless otherwise indicated on Drawings.
7. Support Point: Splice fittings shall be hanger support point.
8. Support Spacing: Support each section at midpoint. Support wall-mounted sections a maximum of one-sixth of the section length from each end.
9. Loading Depth: 4 inches.
10. Maximum Loads: 25 lb/ft..

11. Splicing Assemblies: Bolted type using serrated flange locknuts.
12. Splicing Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
13. Hardware and Fasteners: Steel, zinc plated according to ASTM B 633.
14. Splices and Connectors: Protect cables from edges of center rail and do not intrude into cable fill area.

2.4 MATERIALS AND FINISHES

A. Steel:

1. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A 1011/A 1011M, SS, Grade 33.
2. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
3. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
4. Finish: Mill galvanized before fabrication.

    a. Standard: Comply with ASTM A 653/A 653M, G90.
    b. Hardware: Galvanized, ASTM B 633.

5. Finish: Electrogalvanized before fabrication.

    a. Standard: Comply with ASTM B 633.
    b. Hardware: Galvanized, ASTM B 633.

6. Finish: Hot-dip galvanized after fabrication.

    a. Standard: Comply with ASTM A123/A123 M, Class B2.
    b. Hardware: Chromium-zinc plated, ASTM F 1136.

7. Finish: Epoxy-resin paint.

    a. Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
    b. Epoxy-Resin Prime Coat: Cold-curing epoxy primer, MPI# 101.
    c. Epoxy-Resin Topcoat: Epoxy, cold-cured, gloss, MPI# 77.
    d. Hardware: Chromium-zinc plated. ASTM F 1136.

8. Finish: Factory-standard primer, ready for field painting, with chromium-zinc-plated hardware according to ASTM F 1136.
9. Finish: Black oxide finish for support accessories and miscellaneous hardware according to ASTM D 769.

B. Aluminum:

1. Materials: Alloy 6063-T6 according to ANSI H35.1/H 35.1M for extruded components, and Alloy 5052-H32 or Alloy 6061-T6 according to ANSI H35.1/H 35.1M for fabricated parts.
2. Hardware: Chromium-zinc-plated steel, ASTM F 1136.
3. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F 593 and ASTM F 594.

C. Stainless Steel:

1. Materials: Low-carbon, passivated, stainless steel, Type 304L or Type 316L, ASTM F 593 and ASTM F 594.
2. Hardware for Stainless-Steel Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F 593 and ASTM F 594.

2.5 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Covers: Solid type made of same materials and with same finishes as cable tray.

C. Barrier Strips: Same materials and finishes as for cable tray.

D. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.6 WARNING SIGNS

A. Lettering: 1-1/2-inch- high, black letters on yellow background with legend "Warning! Not To Be Used as Walkway, Ladder, or Support for Ladders or Personnel."

B. Comply with requirements for fasteners in Section 26 05 53 "Identification for Electrical Systems."

2.7 SOURCE QUALITY CONTROL

A. Testing: Test and inspect cable trays according to NEMA FG 1 NEMA VE 1.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

A. Install cable trays according to NEMA VE 2.

B. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.

C. Install cable trays so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.

D. Remove burrs and sharp edges from cable trays.

E. Join aluminum cable tray with splice plates; use four square-neck carriage bolts and locknuts.

F. Fasten cable tray supports to building structure.

G. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of 200 lb. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems."

H. Place supports so that spans do not exceed maximum spans on schedules and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.

I. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.

J. Support bus assembly to prevent twisting from eccentric loading.

K. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.

L. Locate and install supports according to NEMA VE 2. Do not install more than one cable tray splice between supports.

M. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.

N. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA VE 2. Space connectors and set gaps according to applicable standard.

O. Make changes in direction and elevation using manufacturer's recommended fittings.

P. Make cable tray connections using manufacturer's recommended fittings.

Q. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 07 84 00 "Penetration Firestopping."

R. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

S. Install cable trays with enough workspace to permit access for installing cables.

T. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.

U. Install permanent covers, if used, after installing cable. Install cover clamps according to NEMA VE 2.

V. Clamp covers on cable trays installed outdoors with heavy-duty clamps.

W. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.2 CABLE TRAY GROUNDING

A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Cable trays with electrical power conductors shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

C. Cable trays with single-conductor power conductors shall be bonded together with a grounding conductor run in the tray along with the power conductors and bonded to the tray at 72-inch intervals. The grounding conductor shall be sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors," and Article 392, "Cable Trays."

D. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding-bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.

E. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

3.3 CABLE INSTALLATION

A. Install cables only when each cable tray run has been completed and inspected.

B. Fasten cables on horizontal runs with cable clamps or cable ties according to NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.

C. Fasten cables on vertical runs to cable trays every 18 inches.

D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches.

E. Tie MI cables down every 36 inches where required to provide a 2-hour fire rating and every 72 inches elsewhere.

F. In existing construction, remove inactive or dead cables from cable trays.

3.4 CONNECTIONS

A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.

B. Connect raceways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
4. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
7. Check for improperly sized or installed bonding jumpers.

8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

3.6 PROTECTION

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION

SECTION 26 05 43

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Direct-buried conduit, ducts, and duct accessories.
2. Concrete-encased conduit, ducts, and duct accessories.
3. Handholes and boxes.
4. Manholes.

1.3 DEFINITIONS

A. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include duct-bank materials, including separators and miscellaneous components.
2. Include ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Include accessories for manholes, handholes, boxes, and other utility structures.
4. Include warning tape.
5. Include warning planks.

B. Shop Drawings:

1. Precast or Factory-Fabricated Underground Utility Structures:

a. Include plans, elevations, sections, details, attachments to other work, and accessories.
b. Include duct entry provisions, including locations and duct sizes.
c. Include reinforcement details.
d. Include frame and cover design and manhole frame support rings.
e. Include Ladder details.
f. Include grounding details.
g. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
h. Include joint details.

2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:

   a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
   b. Include duct entry provisions, including locations and duct sizes.
   c. Include cover design.
   d. Include grounding details.
   e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.5 INFORMATIONAL SUBMITTALS

A. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.

   1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
   2. Drawings shall be signed and sealed by a qualified professional engineer.

B. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.

C. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.

D. Source quality-control reports.

E. Field quality-control reports.

1.6 MAINTENANCE MATERIALS SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Furnish cable-support stanchions, arms, insulators, and associated fasteners in quantities equal to 5 percent of quantity of each item installed.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

1.8 FIELD CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:

   1. Notify Construction Manager no fewer than two days in advance of proposed interruption of electrical service.
   2. Do not proceed with interruption of electrical service without Construction Manager's written permission.

B. Ground Water: Assume ground-water level is at grade level unless a lower water table is noted on Drawings.

C. Ground Water: Assume ground-water level is 36 inches below ground surface unless a higher water table is noted on Drawings.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR DUCTS AND RACEWAYS

A. Comply with ANSI C2.

2.2 CONDUIT

A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.

B. RNC: NEMA TC 2, Type EPC-40-PVC and Type EPC-80-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.3 NONMETALLIC DUCTS AND DUCT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or a comparable product by one of the following:

1. ARNCO Corp.
2. Beck Manufacturing.
3. Cantex, Inc.
4. CertainTeed Corporation.
5. Condux International, Inc.
6. ElecSys, Inc.
7. Electri-Flex Company.
8. IPEX Inc.
9. Lamson & Sessions; Carlon Electrical Products.
10. Spiraduct/AFC Cable Systems, Inc.

C. Underground Plastic Utilities Duct: NEMA TC 2, UL 651, ASTM F 512, Type EPC-80 and Type EPC-40, with matching fittings complying with NEMA TC 3 by same manufacturer as the duct.

D. Underground Plastic Utilities Duct: NEMA TC 6 & 8, ASTM F 512, UL 651A, Type HDPE and Type EB-20-PVC, with matching fittings complying with NEMA TC 9 by same manufacturer as the duct.

E. Underground Plastic Utilities Duct: NEMA TC 6 & 8, ASTM F 512, Type DB-60-PVC and Type DB-120-PVC, for direct burial, with matching fittings complying with NEMA TC 9 by same manufacturer as the duct.

F. Duct Accessories:

1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and size of ducts with which used, and selected to provide minimum duct spacing indicated while supporting ducts during concreting or backfilling.
2. Warning Tape: Underground-line warning tape specified in Section 26 05 53 "Identification for Electrical Systems."
3. Concrete Warning Planks: Nominal 12 by 24 by 3 inches in size, manufactured from 6000-psi concrete.

a. Color: Red dye added to concrete during batching.
b. Mark each plank with "ELECTRIC" in 2-inch- high, 3/8-inch- deep letters.

2.4 PRECAST CONCRETE HANDHOLES AND BOXES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Christy Concrete Products.
2. Elmhurst-Chicago Stone Co.
3. Oldcastle Precast Group.
4. Rinker Group, Ltd.
5. Riverton Concrete Products.
6. Utility Concrete Products, LLC.
7. Utility Vault Co.
8. Wausau Tile Inc.

C. Comply with ASTM C 858 for design and manufacturing processes.

D. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.

1. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.

2. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
3. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.

    a. Cover Hinges: Concealed, with hold-open ratchet assembly.
    b. Cover Handle: Recessed.

4. Frame and Cover: Weatherproof aluminum frame with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing bolts.

    a. Cover Hinges: Concealed, with hold-open ratchet assembly.
    b. Cover Handle: Recessed.

5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, "ELECTRIC."
7. Configuration: Units shall be designed for flush burial and have closed bottom unless otherwise indicated.
8. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.

    a. Extension shall provide increased depth of 12 inches.
    b. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.

9. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.
10. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks, plus an additional 12 inches vertically and horizontally to accommodate alignment variations.

    a. Windows shall be located no less than 6 inches from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
    b. Window opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
    c. Window openings shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.

11. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

    a. Type and size shall match fittings to duct or conduit to be terminated.
    b. Fittings shall align with elevations of approaching ducts and be located near interior corners of handholes to facilitate racking of cable.

12. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.5 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. General Requirements for Handholes and Boxes: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.

1. Color: Gray.
2. Configuration: Units shall be designed for flush burial and have closed bottom unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, "ELECTRIC."
6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
7. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.

B. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Armorcast Products Company.

    b. Carson Industries LLC.

    c. NewBasis.

    d. Quazite: Hubbell Power System, Inc.

C. Fiberglass Handholes and Boxes with Polymer Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Armorcast Products Company.

    b. Carson Industries LLC.

    c. Christy Concrete Products.

    d. Quazite: Hubbell Power System, Inc.

    e. Synertech Moulded Products, Inc.

D. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers made of polymer concrete.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Carson Industries LLC.

    b. Christy Concrete Products.

    c. Nordic Fiberglass, Inc.

    d. Quazite: Hubbell Power System, Inc.

E. High-Density Plastic Boxes: Injection molded of high-density polyethylene or copolymer-polypropylene. Cover shall be made of polymer concrete.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Carson Industries LLC.

    b. Nordic Fiberglass, Inc.

    c. PenCell Plastics.

    d. Quazite: Hubbell Power System, Inc.

2.6 PRECAST MANHOLES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Christy Concrete Products.

2. Elmhurst-Chicago Stone Co.

3. Oldcastle Precast Group.

4. Rinker Group, Ltd.

5. Riverton Concrete Products.

6. Utility Concrete Products, LLC.

7. Utility Vault Co.

8. Wausau Tile Inc.

C. Comply with ASTM C 858.

D. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.

E. Precast Manholes: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.

F. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks, plus an additional 12 inches vertically and horizontally to accommodate alignment variations.

1. Windows shall be located no less than 6 inches from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
2. Window opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
3. Window openings shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.

G. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

1. Type and size shall match fittings to duct or conduit to be terminated.
2. Fittings shall align with elevations of approaching ducts and be located near interior corners of manholes to facilitate racking of cable.

H. Concrete Knockout Panels: 1-1/2 to 2 inches thick, for future conduit entrance and sleeve for ground rod.

I. Ground Rod Sleeve: Provide a 3-inch PVC conduit sleeve in manhole floors 2 inches from the wall adjacent to, but not underneath, the ducts routed from the facility.

J. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.7 CAST-IN-PLACE MANHOLES

A. Description: Underground utility structures, constructed in place, complete with accessories, hardware, and features. Include concrete knockout panels for conduit entrance and sleeve for ground rod.

B. Materials: Comply with ASTM C 858 and with Section 03 30 00 "Cast-in-Place Concrete."

C. Structural Design Loading: As specified in "Underground Enclosure Application" Article.

2.8 UTILITY STRUCTURE ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Bilco Company (The).
2. Campbell Foundry Company.
3. Christy Concrete Products.
4. East Jordan Iron Works, Inc.
5. Elmhurst-Chicago Stone Co.
6. McKinley Iron Works, Inc.
7. Neenah Foundry Company.
8. NewBasis.
9. Oldcastle Precast Group.
10. Osburn Associates, Inc.
11. Pennsylvania Insert Corporation.
12. Quazite:Hubbell Power Systems, Inc.
13. Rinker Group, Ltd.
14. Riverton Concrete Products.
15. Underground Devices, Inc.
16. Utility Concrete Products, LLC.
17. Utility Vault Co.
18. Wausau Tile Inc.

C. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.

1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B with milled cover-to-frame bearing surfaces; diameter, 26 inches.

   a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
   b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.

2. Cover Legend: Cast in. Selected to suit system.

   a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
   b. Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.

3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.

a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. where packaged mix complying with ASTM C 387, Type M, may be used.
b. Seal joints watertight using preformed plastic or rubber conforming to ASTM C 990. Install sealing material according to the sealant manufacturers' printed instructions.

D. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.

E. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch- diameter eye, and 1-by-4-inch bolt.

1. Working Load Embedded in 6-Inch, 4000-psi Concrete: 13,000-lbf minimum tension.

F. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch- diameter eye, rated 2500-lbf minimum tension.

G. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch- diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.

1. Ultimate Yield Strength: 40,000-lbf shear and 60,000-lbf tension.

H. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch ID by 2-3/4 inches deep, flared to 1-1/4 inches minimum at base.

1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.

I. Ground Rod Sleeve: 3-inch, PVC conduit sleeve in manhole floors 2 inches from the wall adjacent to, but not underneath, the ducts routed from the facility.

J. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch bolt, 5300-lbf rated pullout strength, and minimum 6800-lbf rated shear strength.

K. Cable Rack Assembly: Steel, hot-rolled galvanized, except insulators.

1. Stanchions: T-section or channel; 2-1/4-inch nominal size; punched with 14 holes on 1-1/2-inch centers for cable-arm attachment.
2. Arms: 1-1/2 inches wide, lengths ranging from 3 inches with 450-lb minimum capacity to 18 inches with 250-lb minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
3. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.

L. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.

1. Stanchions: Nominal 36 inches high by 4 inches wide, with minimum of nine holes for arm attachment.
2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches with 450-lb minimum capacity to 20 inches with 250-lb minimum capacity. Top of arm shall be nominally 4 inches wide, and arm shall have slots along full length for cable ties.

M. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F. Capable of withstanding temperature of 300 deg F without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

N. Fixed Manhole Ladders: Arranged for attachment to wall of manhole. Ladder and mounting brackets and braces shall be fabricated from hot-dip galvanized steel.

O. Portable Manhole Ladders: UL-listed, heavy-duty fiberglass specifically designed for portable use for access to electrical manholes. Minimum length equal to distance from deepest manhole floor to grade plus 36 inches. One required.

P. Cover Hooks: Heavy duty, designed for lifts 60 lbf and greater. Two required.

2.9 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.

C. Clear and grub vegetation to be removed, and protect vegetation to remain according to Section 31 10 00 "Site Clearing." Remove and stockpile topsoil for reapplication according to Section 31 10 00 "Site Clearing."

3.2 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical Cables More than 600 V: RNC, NEMA Type EPC-80-PVC, in concrete-encased duct bank unless otherwise indicated.

B. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-80-PVC, in concrete-encased duct bank unless otherwise indicated.

C. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-80-PVC, in direct-buried duct bank unless otherwise indicated.

D. Underground Ducts Crossing Driveways and Roadways: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

3.3 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for 600 V and Less:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-10 structural load rating.
2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10 structural load rating.
4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf vertical loading.
5. Cover design load shall not exceed the design load of the handhole or box.

B. Manholes: Precast or cast-in-place concrete.

1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

3.4 EARTHWORK

A. Excavation and Backfill: Comply with Section 31 20 00 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 32 92 00 "Turf and Grasses" and Section 32 93 00 "Plants."

D. Cut and patch existing pavement in the path of underground ducts and utility structures according to the "Cutting and Patching" Article in Section 01 73 00 "Execution."

3.5 DUCT INSTALLATION

A. Install ducts according to NEMA TCB 2.

B. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes, to drain in both directions.

C. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations unless otherwise indicated.

D. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.

E. Installation Adjacent to High-Temperature Steam Lines: Where duct banks are installed parallel to underground steam lines, perform calculations showing the duct bank will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct bank crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.

F. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch ducts, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell without reducing duct line slope and without forming a trap in the line.
2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line direct-buried duct banks with calculated expansion of more than 3/4 inch.
3. Grout end bells into structure walls from both sides to provide watertight entrances.

G. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet outside the building wall, without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Section 26 05 44 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

H. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.

I. Pulling Cord: Install 100-lbf- test nylon cord in empty ducts.

J. Concrete-Encased Ducts: Support ducts on duct separators.

1. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Section 31 20 00 "Earth Moving" for pipes less than 6 inches in nominal diameter.
2. Width: Excavate trench 12 inches wider than duct bank on each side.
3. Width: Excavate trench 3 inches wider than duct bank on each side.

4. Depth: Install top of duct bank at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
5. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
6. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than four spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
7. Minimum Space between Ducts: 3 inches between ducts and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and signal ducts.
8. Elbows: Use manufactured duct elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run unless otherwise indicated. Extend concrete encasement throughout length of elbow.
9. Elbows: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
    b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.

10. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
11. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
12. Concrete Cover: Install a minimum of 3 inches of concrete cover at top and bottom, and a minimum of 2 inches on each side of duct bank.
13. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.

    a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.
    b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing-rod dowels extending a minimum of 18 inches into concrete on both sides of joint near corners of envelope.

14. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 03 30 00 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.

K. Direct-Buried Duct Banks:

1. Excavate trench bottom to provide firm and uniform support for duct bank. Comply with requirements in Section 31 20 00 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches in nominal diameter.

2. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
3. Space separators close enough to prevent sagging and deforming of ducts, with not less than four spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches between tiers.
4. Depth: Install top of duct bank at least 36 inches below finished grade unless otherwise indicated.
5. Set elevation of bottom of duct bank below frost line.
6. Install ducts with a minimum of 3 inches between ducts for like services and 6 inches between power and signal ducts.
7. Elbows: Install manufactured duct elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
8. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
    b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

9. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 31 20 00 "Earth Moving" for installation of backfill materials.

    a. Place minimum 3 inches of sand as a bed for duct bank. Place sand to a minimum of 6 inches above top level of duct bank.
    b. Place minimum 6 inches of engineered fill above concrete encasement of duct bank.

L. Warning Planks: Bury warning planks approximately 12 inches above direct-buried ducts and duct banks, placing them 24 inches o.c. Align planks along the width and along the centerline of duct bank. Provide an additional plank for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional planks 12 inches apart, horizontally.

M. Warning Tape: Bury warning tape approximately 12 inches above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

3.6 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Cast-in-Place Manhole Installation:

1. Finish interior surfaces with a smooth-troweled finish.

2. Windows for Future Duct Connections: Form and pour concrete knockout panels 1-1/2 to 2 inches thick, arranged as indicated.
3. Comply with requirements in Section 03 30 00 "Cast-in-Place Concrete" for cast-in-place concrete, formwork, and reinforcement.

B. Precast Concrete Handhole and Manhole Installation:

1. Comply with ASTM C 891 unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevations:

1. Manhole Roof: Install with rooftop at least 15 inches below finished grade.
2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch above finished grade.
3. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
4. Where indicated, cast handhole cover frame integrally with handhole structure.

D. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

E. Manhole Access: Circular opening in manhole roof; sized to match cover size.

1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
2. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.

F. Waterproofing: Apply waterproofing to exterior surfaces of manholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Section 07 13 53 "Elastomeric Sheet Waterproofing." After ducts have been connected and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.

G. Dampproofing: Apply dampproofing to exterior surfaces of manholes after concrete has cured at least three days. Dampproofing materials and installation are specified in Section 07 11 13 "Bituminous Dampproofing." After ducts are connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.

H. Hardware: Install removable hardware, including pulling eyes, cable stanchions,cable arms, as required for installation and support of cables and conductors and as indicated.

I. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

J. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.7 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade.

D. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.

E. Field cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

F. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.

1. Concrete: 3000 psi, 28-day strength, complying with Section 03 30 00 "Cast-in-Place Concrete," with a troweled finish.
2. Dimensions: 10 inches wide by 12 inches deep.

3.8 GROUNDING

A. Ground underground ducts and utility structures according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 6-inch- long mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.10 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION

SECTION 26 05 44

SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Section 07 84 00 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit EQ 4: For sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.

2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

F. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Advance Products & Systems, Inc.
b. CALPICO, Inc.
c. Metraflex Company (The).
d. Pipeline Seal and Insulator, Inc.
e. Proco Products, Inc.

3. Sealing Elements: EPDM Nitrile (Buna N) rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
4. Pressure Plates: Carbon steel.
5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, Stainless steel of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Presealed Systems.

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
2. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

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

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

    a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 07 92 00 "Joint Sealants."

b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION

SECTION 26 05 48

VIBRATION CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Isolation pads.
2. Spring isolators.
3. Restrained spring isolators.
4. Channel support systems.
5. Restraint cables.
6. Hanger rod stiffeners.
7. Anchorage bushings and washers.

B. Related Sections include the following:

1. Section 26 05 29 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.3 DEFINITIONS

A. The IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

3. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.

4. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
5. Field-fabricated supports.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

B. Qualification Data: For professional engineer and testing agency.

C. Field quality-control test reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

E. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
3. California Dynamics Corporation.

4. Isolation Technology, Inc.
5. Kinetics Noise Control.
6. Mason Industries.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
9. Vibration Mountings & Controls, Inc.

D. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

E. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.2 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.
2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment and Hanger Restraints:

1. Install restrained isolators on electrical equipment.
2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

C. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

D. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.

4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust isolators after isolated equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 26 05 48

SECTION 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Section 26 27 26 Wiring Devices for receptacle identification requirements (262726-3.3.B).

1.2 SUMMARY

A. Section Includes:

1. Identification for conduit and raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification nameplates.
8. Labels
9. Lockout Devices
10. Miscellaneous identification products.

1.3 ACTION SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Samples: For each type of label and sign submit (2) samples to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels. Submit electrical identification schedule including list of wording, symbols, letter size, color coding, tag number, location, and function.

D. Manufacturer's installation instructions: Indicate installation instructions, special procedures, and installation.

1.4 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

F. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

G. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum 3 years experience.

H. Installer: Company specializing in performing Work of this section with minimum 3 years experience.

I. Delivery, Storage, and Handling: Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.

J. Delivery, Storage, and Handling: Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.5 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 POWER AND CONTROL CONDUIT AND RACEWAY IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

B. Colors for Raceways Carrying Circuits at 600 V or Less:
   1. Legend: Indicate voltage and system or service type including,
      a. Normal source: black letters on white contrasting background color
      b. Emergency source: red letters on white contrasting background color
      c. High Voltage Systems (above 600V): black letters on yellow contrasting background color.
      d. Communication Systems: black letters on orange contrasting background color.
      e. UPS source: blue letters on white
   2. Conduits shall be color coded according to service. The color coding scheme (basis of design is as follows) shall be approved prior to installation or purchase of materials.
      a. Normal power (208V and 480V): standard conduit

b. Fire alarm system: red
c. Emergency power (generator): yellow
d. UPS power (208V and 480V): blue
e. Data, A/V: orange

C. Colors for Raceways Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.
2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING."

D. Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing ends of legend label.

E. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

F. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

G. Tape and Stencil for Raceways Carrying Circuits More Than 600 V: 4-inch- wide black stripes on 10-inch centers diagonally over orange background that extends full length of raceway or duct and is 12 inches wide. Stop stripes at legends.

H. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.

I. Write-On Tags: Polyester tag, 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.2 ARMORED AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each cable size.

B. Colors for Cables Carrying Circuits at 600 V and Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

C. Colors for Cables Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.
2. Legend: "DANGER HIGH VOLTAGE WIRING."

D. Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing ends of legend label.

E. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded for outdoor use.

F. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tube with machine-printed identification label. Sized to suit diameter of and shrinks to fit firmly around cable it identifies. Full shrink recovery at a maximum of 200 deg F. Comply with UL 224.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each cable size.

B. Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing ends of legend label.

C. Self-Adhesive, Self-Laminating Polyester Labels: Preprinted, 3-mil- thick flexible label with acrylic pressure-sensitive adhesive that provides a clear, weather- and chemical-resistant, self-laminating, protective shield over the legend. Labels sized to fit the cable diameter such that the clear shield overlaps the entire printed legend.

D. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tube with machine-printed identification label. Sized to suit diameter of and shrinks to fit firmly around cable it identifies. Full shrink recovery at a maximum of 200 deg F. Comply with UL 224.

E. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.

F. Write-On Tags: Polyester tag, 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

G. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of cable it identifies and to stay in place by gripping action.

H. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of cable it identifies and to stay in place by gripping action.

2.4 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

B. Self-Adhesive, Self-Laminating Polyester Labels: Preprinted, 3-mil- thick flexible label with acrylic pressure-sensitive adhesive that provides a clear, weather- and chemical-resistant, self-laminating, protective shield over the legend. Labels sized to fit the conductor diameter such that the clear shield overlaps the entire printed legend.

C. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of conductor it identifies and to stay in place by gripping action.

D. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve with diameter sized to suit diameter of conductor it identifies and to stay in place by gripping action.

E. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tube with machine-printed identification label. Sized to suit diameter of and shrinks to fit firmly around conductor it identifies. Full shrink recovery at a maximum of 200 deg F. Comply with UL 224.

F. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

G. Write-On Tags: Polyester tag, 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
2. Labels for Tags: Self-adhesive label, machine-printed with permanent, waterproof, black ink recommended by printer manufacturer, sized for attachment to tag.

H. Power and Lighting Circuits: Branch circuit or feeder number as indicated on Drawings.

I. Control Circuits: Control wire number as indicated on schematic and interconnection diagrams.

2.5 FLOOR MARKING TAPE

A. 2-inch- wide, 5-mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.

2.6 UNDERGROUND-LINE WARNING TAPE

A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Inscriptions for Red-Colored Tapes:
   a. ELECTRIC LINE
   b. HIGH VOLTAGE
3. Inscriptions for Orange-Colored Tapes:
   a. TELEPHONE CABLE
   b. CATV CABLE
   c. COMMUNICATIONS CABLE
   d. OPTICAL FIBER CABLE

C. Tag: Type I:

1. Pigmented polyolefin, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Thickness: 4 mils.
3. Weight: 18.5 lb/1000 sq. ft..
4. 3-Inch Tensile According to ASTM D 882: 30 lbf, and 2500 psi.

D. Tag: Type II:

1. Multilayer laminate consisting of high-density polyethylene scrim coated with pigmented polyolefin, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Thickness: 12 mils.
3. Weight: 36.1 lb/1000 sq. ft..
4. 3-Inch Tensile According to ASTM D 882: 400 lbf, and 11,500 psi.

E. Tag: Type ID:

1. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Overall Thickness: 5 mils.
3. Foil Core Thickness: 0.35 mil.
4. Weight: 28 lb/1000 sq. ft..
5. 3-Inch Tensile According to ASTM D 882: 70 lbf, and 4600 psi.

F. Tag: Type IID:

1. Reinforced, detectable three-layer laminate, consisting of a printed pigmented woven scrim, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Overall Thickness: 8 mils.
3. Foil Core Thickness: 0.35 mil.
4. Weight: 34 lb/1000 sq. ft..
5. 3-InchTensile According to ASTM D 882: 300 lbf, and 12,500 psi.

2.7 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.

3. Nominal size, 7 by 10 inches.

D. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.

3. Nominal size, 10 by 14 inches.

E. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.8 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. inches and 1/8 inch thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

2.9 EQUIPMENT IDENTIFICATION NAMEPLATES

A. Product Description: Laminated three-layer plastic with engraved letters on contrasting background color.
1. Normal Systems: black letters on white contrasting background color.
2. Emergency Systems: red letters on white contrasting background color.
3. High Voltage Systems (above 600V): black letters on yellow contrasting background color.
4. Communication Systems: black letters on orange contrasting background color.

B. Letter Size:
1. 1/4inch high letters for identifying individual equipment and loads.
2. 1/4inch high letters for identifying grouped equipment and loads.

C. Minimum nameplate thickness: 1/8”.

2.10 LABELS

A. Adhesive Film Label (Plastic adhesive tape): Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/16 inch.
1. Normal Systems: black letters on white contrasting background color.
2. Emergency Systems: red letters on white contrasting background color.

3. High Voltage Systems (above 600V): black letters on yellow contrasting background color.
4. Communication Systems: black letters on orange contrasting background color.

B. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/16 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

C. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.11 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.

C. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F, According to ASTM D 638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

2.12 LOCKOUT DEVICES

A. Lockout hasps: Anodized aluminum hasp with erasable label surface; size minimum 7-1/4 x 3 inches.

2.13 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Install labels and nameplates only when ambient temperature and humidity conditions for adhesive are within range recommended by manufacturer.

E. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

F. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

G. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape with adhesive appropriate to the location and substrate.

H. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

I. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

J. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

K. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

L. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

A. Underground conduit (power and telecomm) stub ups or penetrations within manholes and buildings (other than within gear) including stub ups within TRs and electrical rooms fed from within facility: Install brass tag each end identifying location fed from.

B. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 120 V to ground: Identify with self-adhesive vinyl label. Install labels at 20-foot maximum intervals.

C. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:

1. Normal source
2. Emergency source
3. UPS source

D. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.

a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
b. Colors for 208/120-V Circuits:

1) Phase A: Black.
2) Phase B: Red.
3) Phase C: Blue.
4) Neutral: White.
5) Ground: Green.
6) Iso Ground: Green/Yellow.

c. Colors for 480/277-V Circuits:

1) Phase A: Brown.
2) Phase B: Orange.
3) Phase C: Yellow.
4) Neutral: Gray.
5) Ground: Green.
6) Iso Ground: Green/Yellow.

d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

E. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

F. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive, self-laminating polyester labels with the conductor or cable designation, origin, and destination.

G. Control-Circuit Conductor Termination Identification: For identification at terminations provide heat-shrink preprinted tubes with the conductor designation.

H. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.

I. Data wiring identification:
   1. Mark data cabling at each end. Install additional marking at accessible locations along the cable run.
   2. Install labels at data outlets identifying patch panel and port designation as indicated on drawings.

J. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

   1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
   2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
   3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

K. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.

   1. Limit use of underground-line warning tape to direct-buried cables.
   2. Install underground-line warning tape for both direct-buried cables and cables in raceway.

L. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

M. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.

   1. Comply with 29 CFR 1910.145.
   2. Identify system voltage with black letters on an orange background.
   3. Apply to exterior of door, cover, or other access.
   4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:

      a. Power transfer switches.
      b. Controls with external control power connections.

N. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

O. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for power transfer.

P. Nameplate Installation:
   1. Install nameplate parallel to equipment lines.
   2. Install nameplate for each electrical distribution and control equipment enclosure located inside with corrosive-resistant mechanical fasteners or adhesive.
   3. Install nameplates for each control panel and major control components located outside panel with corrosive-resistant mechanical fasteners or adhesive.
   4. Secure nameplate to equipment with screws or adhesive (indoors only).
   5. Secure nameplate to inside surface of door on recessed panelboard in finished locations.

Q. Label Installation:
1. Install label parallel to equipment lines.
2. Install label on each control station and wiring device with panel and circuit assignment including,
   a. Receptacles (per 262726.3.3.B)
   b. Wall switches (including light switches, shade controls, and similar control devices)

R. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

   a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where two lines of text are required, use labels 2 inches high.
   b. Outdoor Equipment: Stenciled legend 4 inches high.
   c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
   d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment to Be Labeled:

   a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be engraved, laminated acrylic or melamine label.
   b. Enclosures and electrical cabinets.
   c. Access doors and panels for concealed electrical items.
   d. Service disconnects – DISC
   e. Automatic transfer switches - ATS
   f. Switchgear.
   g. Switchboards / Distribution Boards - DP.
   h. Transformers - TX: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
   i. Emergency system boxes and enclosures.
   j. Motor-control centers - MCC.
   k. Enclosed switches.
   l. Enclosed circuit breakers.
   m. Enclosed controllers.
   n. Variable-speed controllers.
   o. Push-button stations.
   p. Power transfer equipment.
   q. Contactors.
   r. Battery-inverter units.
   s. Battery racks.
   t. Power-generating units.
   u. Monitoring and control equipment.
   v. UPS equipment.

END OF SECTION

SECTION 26 05 73.16

OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

1. Study results shall be used to determine coordination of series-rated devices.

1.3 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.

1. Coordination-study input data, including completed computer program input data sheets.
2. Study and equipment evaluation reports.
3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.

a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Coordination Study Specialist.

B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

a. The following parts from the Protective Device Coordination Study Report:

1) One-line diagram.
2) Protective device coordination study.
3) Time-current coordination curves.

b. Power system data.

1.7 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Coordination Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Coordination Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing

laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Software Developers: Subject to compliance with requirements, provide software by the following:

1. ESA Inc.
2. Operation Technology, Inc.
3. Power Analytics, Corporation.
4. SKM Systems Analysis, Inc.

B. Comply with IEEE 242 and IEEE 399.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

1. Optional Features:

a. Arcing faults.
b. Simultaneous faults.
c. Explicit negative sequence.
d. Mutual coupling in zero sequence.

2.2 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study:

1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

    a. Voltage.
    b. Calculated fault-current magnitude and angle.
    c. Fault-point X/R ratio.
    d. Equivalent impedance.

2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

    a. Voltage.
    b. Calculated symmetrical fault-current magnitude and angle.
    c. Fault-point X/R ratio.
    d. Calculated asymmetrical fault currents:

        1) Based on fault-point X/R ratio.
        2) Based on calculated symmetrical value multiplied by 1.6.
        3) Based on calculated symmetrical value multiplied by 2.7.

3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

    a. Voltage.
    b. Calculated symmetrical fault-current magnitude and angle.
    c. Fault-point X/R ratio.
    d. No AC Decrement (NACD) ratio.
    e. Equivalent impedance.
    f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
    g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

F. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.

    a. Phase and Ground Relays:

        1) Device tag.
        2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
        3) Recommendations on improved relaying systems, if applicable.

    b. Circuit Breakers:

        1) Adjustable pickups and time delays (long time, short time, ground).
        2) Adjustable time-current characteristic.
        3) Adjustable instantaneous pickup.
        4) Recommendations on improved trip systems, if applicable.

    c. Fuses: Show current rating, voltage, and class.

G. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:

    a. Power utility's overcurrent protective device.
    b. Medium-voltage equipment overcurrent relays.
    c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
    d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
    e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
    f. Cables and conductors damage curves.
    g. Ground-fault protective devices.
    h. Motor-starting characteristics and motor damage points.
    i. Generator short-circuit decrement curve and generator damage point.
    j. The largest feeder circuit breaker in each motor-control center and panelboard.

5. Series rating on equipment allows the application of two series interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Both devices share in the interruption of the fault and selectivity is sacrificed at high fault levels. Maintain selectivity for tripping currents caused by overloads.
6. Provide adequate time margins between device characteristics such that selective operation is achieved.
7. Comments and recommendations for system improvements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 PROTECTIVE DEVICE COORDINATION STUDY

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. The study shall be based on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.
2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:

a. Inrush current when first energized.
b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

H. Motor Protection:

1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
2. Select protection for motors served at voltages more than 600 V according to IEEE 620.

I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

J. Generator Protection: Select protection according to manufacturer's written recommendations and to IEEE 242.

K. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

L. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:

1. Electric utility's supply termination point.
2. Switchgear.
3. Unit substation primary and secondary terminals.
4. Low-voltage switchgear.
5. Motor-control centers.
6. Standby generators and automatic transfer switches.
7. Branch circuit panelboards.

M. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
3. Any application of series-rated devices shall be recertified, complying with requirements in NFPA 70.

3.3 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the overcurrent protective device study.

1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. For existing equipment, whether or not relocated obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.

B. Gather and tabulate the following input data to support coordination study. The list below is a guide. Comply with recommendations in IEEE 241 and IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Electrical power utility impedance at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus, three phase and line-to-ground.
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.

8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Maximum demands from service meters.
13. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
14. Motor horsepower and NEMA MG 1 code letter designation.
15. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
16. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.
17. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:

    a. Special load considerations, including starting inrush currents and frequent starting and stopping.
    b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
    c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
    d. Generator thermal-damage curve.
    e. Ratings, types, and settings of utility company's overcurrent protective devices.
    f. Special overcurrent protective device settings or types stipulated by utility company.
    g. Time-current-characteristic curves of devices indicated to be coordinated.
    h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
    i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
    j. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.
    k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

3.4 FIELD ADJUSTING

A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.

B. Make minor modifications to equipment as required to accomplish compliance withprotective device coordination studies.

C. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

END OF SECTION 26 05 73.16

SECTION 26 05 73.19

OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.3 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form.

1. Arc-flash study input data, including completed computer program input data sheets.
2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.

    a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Arc-Flash Study Specialist.

B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.

B. Operation and Maintenance Procedures: In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.7 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Software Developers: Subject to compliance with requirements, provide software by one of the following:

1. ESA Inc.
2. Operation Technology, Inc.
3. Power Analytics, Corporation.

4. SKM Systems Analysis, Inc.

B. Comply with IEEE 1584 and NFPA 70E.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENT

A. Executive summary.

B. Study descriptions, purpose, basis and scope.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output:

1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. No AC Decrement (NACD) ratio.
e. Equivalent impedance.
f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

F. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.
2. Protective device clearing time.
3. Duration of arc.
4. Arc-flash boundary.
5. Working distance.
6. Incident energy.
7. Hazard risk category.
8. Recommendations for arc-flash energy reduction.

G. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

2.3 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems." Produce a 3.5-by-5-inch (76-by-127-mm) thermal transfer label of high-adhesion polyester for each work location included in the analysis.

B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1. Location designation.
2. Nominal voltage.
3. Flash protection boundary.
4. Hazard risk category.
5. Incident energy.
6. Working distance.
7. Engineering report number, revision number, and issue date.

C. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 SHORT-CIRCUIT STUDY

A. Perform study following the general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.
2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems.

H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:

1. Electric utility's supply termination point.
2. Switchgear.
3. Unit substation primary and secondary terminals.
4. Low-voltage switchgear.
5. Motor-control centers.
6. Standby generators and automatic transfer switches.
7. Branch circuit panelboards.

3.3 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Use the short-circuit study output and the field-verified settings of the overcurrent devices.

C. Calculate maximum and minimum contributions of fault-current size.

1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.

E. Include medium- and low-voltage equipment locations, except 240-V ac and 208-V ac systems fed from transformers less than 125 kVA.

F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.

G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond three to five cycles.
2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).

H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:

1. When the circuit breaker is in a separate enclosure.
2. When the line terminals of the circuit breaker are separate from the work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.4 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.

1. Verify completeness of data supplied on the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers.

B. Gather and tabulate the following input data to support coordination study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in per cent, and phase shift.
5. For reactors, provide manufacturer and model designation, voltage rating and impedance.
6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
8. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
9. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
10. Motor horsepower and NEMA MG 1 code letter designation.
11. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
12. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.

3.5 LABELING

A. Apply one arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:

1. Motor-control center.
2. Low-voltage switchboard.
3. Switchgear.
4. Medium-voltage switch.
5. Control panel.

3.6 APPLICATION OF WARNING LABELS

A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

3.7 DEMONSTRATION

A. Engage the Arc-Flash Study Specialist to train Owner's maintenance personnel in the potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

END OF SECTION 26 05 73.19

SECTION 26 09 13
ELECTRICAL POWER MONITORING

PART 1 - GENERAL

1.1 SCOPE

A. This section defines low voltage power metering for use in AC systems. These low voltage power meters may be applied on systems rated 600 V or less without PT's or on higher voltage systems with PT's.

1.2 RELATED DOCUMENTS

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

B. Related Sections include the following:
   1. Section 26 09 36 – Lighting Controls
   2. Section 26 24 13 – Switchboard
   3. Section 26 24 16 – Panelboards
   4. Section 26 08 00 - Commissioning of Emergency Power Systems and Lighting Controls

1.3 SUBMITTALS

A. Submit shop drawings and product data for approval and final documentation in the quantities listed according to the Conditions of the Contract. Customer name, customer location and customer order number shall identify all transmittals.

B. Final Documents: Record documentation to include wiring diagrams, instruction and installation manuals.

1.4 RELATED STANDARDS

A. Meet the following recognized standards for application in hardened environments:
   1. Device must meet all international standards for Safety and Construction applicable to this type of device:
      a. ANSI C12.20, 0.5% Revenue requirements
      b. IEC61557-12 accuracy certified samples at over 2048 per 10/12 cycles samples per cycle.
   2. The meter shall also meet the followings standard compliances:
      a. UL, CSA and CE Approvals:
         1.) UL 61010-1, 2nd Ed.
         2.) CAN/CSA-C22.2 NO. 61010-1-04, 2nd Ed.
         3.) CE approved.
         4.) Class 0.2 S acc. to IEC61557-12. (Correlates to IEC62053-22)
   3. The meter shall meet the following Safety / Construction Standards:
      a. IEC1010-1 (EN61010-1): Safety Requirements for Electrical Equipment, Control and Laboratory Use.
      b. CAN/CSA C22.2 No. 61010-1-04, 2nd Ed.: Safety requirements of Canadian Standard Association.

1.5 QUALITY ASSURANCE.

A. Manufacturer Qualifications: Manufacturer of this equipment shall have a minimum of 5 years experience producing similar electrical equipment.
   1. Comply with requirements of latest revisions of applicable industry standards.

1.6 DELIVERY, STORAGE AND HANDLING

A. Store and handle in strict compliance with manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. If the meters are

installed in equipment, store the equipment so condensation will not form on or in it. If necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Siemens

B. Square D

C. Eaton

D. GE

2.2 COMPONENTS

A. Revenue accurate multifunction power meter.

1. Provide a high accuracy power meter meeting the requirements set forth in this specification. Note any exceptions taken with a detailed description.
    a. Meter shall be Siemens Type SENTRON PAC4200 Power Meter with options and features described in this section or approved equal.
2. The meter shall have at least the following features:
    a. Current inputs: The meter shall accept three 5A nominal current inputs. The current inputs are capable of measuring up to 5A RMS (300V RMS maximum voltage). All current inputs provide:
        1.) Dielectric withstand of 3000Vrms 47-63 Hz for 1 minute.
        2.) Surge protection of 120 A RMS for 1 second, non-recurring.
    b. The meter shall have three voltage inputs (V1, V2, and V3). The voltage inputs can measure from 0 to 400 Vrms (line-to-neutral) or from 0 to 690 Vrms (line-to-line).
    c. The meter shall have provisions for direct connection (require no PTs) for Wye (Star) systems up to 400 VAC (line-to-neutral) or 690 VAC (line-to-line). All voltage inputs provide:
        1.) Dielectric withstand of 3250 VAC RMS, 60 Hz for 1 minute.
        2.) Overload protection of 1500 VAC RMS continuous.
    d. Power supply:
        1.) 95 - 240 VAC (±10%), 50 to 60 Hz
    e. Typical burden is 6 VA, maximum burden is 8 VA. Dielectric withstand is 2000 VAC RMS, 60 Hz for 1 minute.
    f. The meter shall provide for Ring Tongue or Screw terminals to meet various regulations.
    g. Operating frequency: 45 to 64 Hz.
    h. Standard Communications port shall be a RJ45 Modbus TCP 10/100BaseT Copper Ethernet communication. The metering instrument shall have the following optional communications ports:
        1.) *Profibus DP* Profibus DP will programmable to communicate 9600 BPS to 12 MPBS with supplied .GSD file.
        2.) *Modbus RTU (RS-485) serial* Modbus will be programmable to communicate at speeds from 4800 to 38.4 bits per second
    i. The meter shall support broadcast messages from a host computer system.
    j. The meter shall provide as “standard” the following Inputs/Outputs:
        1.) Two Digital Input – rated at 24 VDC / 0.7mA
        2.) Two Digital Output – rated 12-24 VDC, 0-10mA
    k. A universal counter shall be designed into the meter to count pulses coming into the digital inputs for measuring variables such as Water, Gas, Air, etc.
    l. Sample Rate shall be at least 2048 samples per cycle.

m. Meter shall support multiple languages including English, German, French, Spanish, Italian, Portuguese, Turkish, Chinese and Russian.
n. Meter design shall be:
1.) A background-illuminated graphic LCD sized 128 x 96mm.
2.) An overview size of 3.78”L x 3.78”W (96 x 96mm) and a depth of 2.00” (51mm), with an optional module added the depth shall be 2.87” (73mm).
o. Basic meter design shall provide for (2) two expansion slots.

2.3 OVERVIEW

A. The meter shall be able to be upgraded in the field without removing the meter.

B. The meter shall measure the following variables as standard without optional plug in modules or optional cards;
1. Basic Measurements
a. Voltage (l-n) per phase, Voltage (l-l) per phase, Voltage (l-l) average, Voltage (l-n) average, Current per phase, Current average total, Active Power (kW) per phase and total, Apparent Power (kVa) per phase and total, Reactive Power (kVAR) per phase and total,
2. Advanced Measurements (Included)
a. Power factor (per phase and total), Voltage THD per phase, Current THD per phase, Frequency, total active power demand import/export; Meter running counter, universal counter, limit alarming for 6 values
3. Min/Max Values
a. Voltage (l-n) per phase, Voltage (l-l) per phase, Average Voltage (l-l) and (l-n) total; Current per phase, Active Power (kW) per phase and total, Apparent Power (kVa) per phase and total, Reactive Power (kVAR) per phase and total, Power factor (per phase and total), Voltage THD per phase, Current THD per phase, Frequency,
4. Energy Measurements
a. Energy (kWh) import/export , high/low tariff; Apparent energy (kVAh), high/low tariff; Reactive energy (kVARh) import/export, high/low tariff Peak power demand (kW), Current demand, Peak current demand, Neutral current, Reactive power (kVAR) peak demand, Apparent power (kVA) peak demand,.

C. The meter shall calculate the following information for any reading at 1-second intervals:
1. Sliding window demands for any parameter with user-programmable length of demand period.
2. Number of sub-periods to match local utility billing method.

D. The meter shall display “actual” readings on the display. No manual calculation shall be required to obtain actual readings.

E. The meter shall display all measured parameters on the front display.

F. Harmonic Bar Charts shall be available on the display.

G. Phasor Diagram shall be available on the display to provide fast system diagnostics.

H. Remote access to all metering parameters shall be available through the Ethernet communications port and Serial port at the same time.

I. Meter shall provide as standard the ability to customize up to four screens.

J. The meter shall act as a “Gateway” allowing up to 32 Modbus serial to be connected to the meter and the data passed to the Ethernet LAN.

K. An internal Clock shall be provided to allow time and date stamping of data.

L. The meter shall have the ability to monitor as least twelve (12) different set points for alarming. These include: V, I, Power, VAR, VA, Freq, THD and PF.

M. Standard logic functionality shall be available in the meter for setting up custom alarms that can be sent out via the digital output or through the communications port.

N. The meters shall be field programmable as follows:
   1. Basic parameters: Voltage input scale, voltage mode (Wye, Delta, single phase), current input scale, auxiliary input and output scales, and communications setup parameters are programmable from the front panel.
   2. All basic parameters described above may be programmed via the communications port using a portable or remotely located computer terminal.
   3. Provisions must be made to ensure that programming through a computer can be secured by user ID and password.
   4. Provisions must be made to ensure that programming through the front panel is secured by password.

O. The meter shall include flash memory to store in non-volatile memory the following:
   1. All setup data
   2. Accumulated energy and demand data.

P. The meter shall include data and event logging, as follows:
   1. Kw, kWd, Min/Max values for up to 40 days at 15 min intervals.
   2. Event logging for up to 4096 operations.
   3. Logs shall be first in first out or fixed.
   4. Date and time synchronization shall be through the digital input, communication interfaces or internal clock.

Q. Storage of load demand values
   1. Meter shall have storage capacity of up to 4096 operation, control or system events
   2. Power demand values (load profile) for apparent, active and reactive power for 4 month with minimum & maximum values at a 15min. measuring period
   3. Total reactive power, fundamental reactive power or distorted reactive power, selectable
   4. Arithmetic or cumulated power demand values could be calculated
   5. Synchronization via digital input, communication interfaces or internal clock
   6. Supports fixed or rolling block method.

2.4 DESIGN

PART 3 - EXECUTION

3.1 INSTALLATION

A. The Contractor shall furnish, install and terminate all communication conductors and associated conduits external to any factory supplied equipment.

B. All communication conductor wiring and routing shall be per the manufacturer's recommendations and as shown on the contract drawings.

C. *Additional connections to metering systems, where applicable, shall be done in the field by the manufacturer's start-up service group.*

3.2 ADJUSTING AND CLEANING

A. The meters shall be adjusted so that accurate readings appear on the front of the meter and that the readings are within the meters accuracy range.

B. Clean exposed surfaces using manufacturer recommended materials and methods.

3.3 TESTING

A. Perform factory and installation tests in accordance with applicable NEC, NEMA and UL requirements.

3.4 WARRANTY

A. Equipment manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of initial operation, but not more than eighteen months from date of shipment.

3.5 STARTUP SERVICES

A. Engage a factory-authorized service representative to perform startup service.

B. Train Owner's maintenance personnel on procedures and schedules for energizing and de-energizing, troubleshooting, servicing and maintaining equipment and schedules.

C. Verify that the meters are installed and connected according to the Contract Documents.

D. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing. Verify that wiring installation complies with requirements in Division 26 Sections.

E. Complete installation and startup checks according to manufacturer's written instructions.

3.6 SUPPORT

A. The electrical equipment manufacturer shall provide a 1-800 number for telephone support.

B. PMCS Vendor shall provide training at a dedicated training facility within their Power Monitoring Headquarters, complete with software, devices and demonstrations.

C. The PMCS vendor shall also provide on-line support for technical information and literature.

END OF SECTION

SECTION 26 22 13

LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 GENERAL

1.1 SUMMARY

A. Furnish and install, where indicated on the drawings, dry type transformers with the voltages and phases as shown on the drawings. Transformers shall be 60 Hz with KVA rating as shown on the drawings.

PART 2 DESIGN STANDARDS

2.1 GENERAL

A. Acceptable transformer manufacturers are Square D, Eaton, GE, Siemens.

B. Transformers shall comply with the latest NEMA and ANSI standards, Nema TP-1.

C. Provide copper (or aluminum) windings, electrostatic shielded, class 220 insulation, 150 degrees Celsius temperature rise, K-4 or K-13 (when indicated).

D. Transformers shall be encased in a sheet steel enclosure; 10 KVA and smaller shall be non-ventilated, and above 10 KVA shall be ventilated, self-cooled. The core and coil assembly shall be completely isolated from the enclosure by means of neoprene rubber isolation pads or other acceptable vibration isolators. In addition, all transformers shall be mounted on vibration isolators. Acceptable transformer manufacturers are General Electric, Siemens, Square D, Cutler-Hammer.

E. Transformer(s) for non-linear loads shall be UL listed and labeled for (K-4). Neither the primary nor the secondary temperature shall exceed 220 degrees Celsius at any point in the coils while carrying their full rating of non-sinusoidal load. All cores shall be constructed with low hysteresis and eddy current losses. The core flux density shall be well below the saturation point to prevent overheating and excessive sound level caused by harmonic noise distortion. Three phase transformer secondary neutral terminals shall be sized for 200% of the secondary phase current.

F. Provide manufacturer's standard light gray indoor enamel over phosphatized steel enclosure.

G. Provide weather shields for outdoor installations.

H. Provide vibration mounts (300 KVA and below).

I. Drive isolation transformers shall be configured with delta primary and wye secondary.

2.2 INSULATION

A. Transformers up to 30 KVA shall have a 185 degrees Celsius insulation system and shall not exceed 115 degrees Celsius rise above a 40 degrees Celsius ambient under full load conditions. Above 30 KVA, transformers shall have a 220 degrees Celsius insulation system and shall not exceed 150 degrees Celsius rise above a 40 degrees Celsius ambient under full load condition.

B. Transformer insulation for non-linear loads shall be a UL recognized 220 degrees Celsius system. Transformer(s) evaluated by the K-factor evaluation shall be listed for 115 degrees Celsius average temperature rise only. Transformers with K-factor temperature rise of 150 degrees Celsius shall not be acceptable.

C. Transformers shall be capable of operating at 100% of nameplate rating continuously while in an ambient temperature not exceeding 40 degrees Celsius.

2.3 TAPS

A. Transformers rated 25 KVA and below shall have two 5% taps below normal. Transformers rated 30 KVA and larger shall have six 2-1/2% taps, four below, and two above normal.

2.4 SOUND OUTPUT

A. Sound outputs of transformers shall not exceed the following levels, based on NEMA standard testing procedures:

KVA Rating	Decibel Sound Output
0 - 9	40
10 - 50	45
51 - 150	50
151 - 300	55
301 - 500	60

END OF SECTION

SECTION 26 23 00
SERVICE ENTRANCE SWITCHBOARDS
(RATED 480V AND BELOW)

I. GENERAL

1. RELATED DOCUMENTS

   A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

2. ATTACHMENTS

   A. See electrical plans

3. DESCRIPTION OF WORK

   A. The work covered by the following specification shall include the furnishing of all labor, material, equipment, services, and design required to deliver Switchboards described herein and on drawings, schedules, and Data Sheets.

4. CODES AND STANDARDS

   A. NEC Compliance: Comply with NEC as applicable to wiring methods, construction and installation of low voltage Switchgear assemblies.

   B. NEMA Compliance: Comply with applicable requirements of NEMA Stds Pub/No. SG-3, "Low-Voltage Power Circuit Breakers", and SG-5 "Power Switchgear Assemblies".

   C. UL Compliance: Comply with applicable requirements of UL 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors". Provide equipment and components which are UL-listed and labeled.

   D. ANSI Compliance: Comply with ANSI requirements as applicable to construction and installation of low voltage Switchgear.

   E. IEEE Compliance: Comply with applicable requirements of IEEE Std 241, "Recommended Practice for Electric Power Systems in Commercial Buildings", pertaining to low voltage Switchgear.

   F. Utility Specifications: Comply with utility construction specifications, latest edition in force.

5. SUBMITTALS

A. Product Data: Submit manufacturer's technical product data, including, but not limited to, specifications, service voltages, number of phases, main bus current ratings and interrupting capacities, furnished specialties and accessories for low voltage switchgear. Also provide metering equipment types and their operational capabilities.

B. Shop Drawings: Submit shop drawings and catalog cuts required for the fabrication and installation of the equipment for Engineer's approval prior to fabrication and shipment (5 sets of 'D' size drawings). Shop drawings and catalog cuts shall be clearly identified with the Owner's name, job location, project title, specification, and project number. Submit dimensioned drawings of indoor Switchgear, showing layout of equipment, location of conduit and cable or bus duct connections, weight loading, required clearances, and methods of assembly of components. Submit (6) copies, including (1) reproducible copy.

C. Operation and Maintenance (O & M) Manuals: Furnish (6) copies of an instruction manual for installation, operation, maintenance, and lubrication requirements for each component of the mechanical and electrical equipment. Include one O & M manual with the shipment of the Switchgear. Each instruction manual furnished shall be bound in hard-back cover or file folder. Clearly label the manual to designate the equipment for which it is intended. Reference the equipment number and the Specification section where the item is specified.

Each manual shall include, but not be limited to, the following information:

(a) Diagrams and illustrations.

(b) Performance and nameplate data.

(c) Installation instructions.

(d) Test procedures.

(e) Procedure for operating.

(f) Shutdown instructions.

(g) Emergency operating instructions and troubleshooting guide.

(h) Safety precautions.

(i) Maintenance and overhaul instructions.

(j) Recommended spare parts list.

(k) Lubrication instructions listing points to be greased or oiled..

D. Factory Test Data: Provide factory test data, certified by a Professional Engineer, that low voltage Switchgear test results fulfill specified requirements.

6. DELIVERY, STORAGE, AND HANDLING

A. Preparation for shipment:

1) Insofar as is practical, equipment shall be factory assembled. The equipment parts and assemblies that are, of necessity, shipped unassembled shall be furnished with an assembly plan and instructions. The separate parts and assemblies shall be match-marked or tagged in a manner to facilitate field assembly of the equipment.

2) Generally, machined and unpainted parts subject to damage by the elements shall be protected with an application of a strippable protective coating.

3) Equipment shall be packaged or crated in a manner that will provide protection from damage during shipping, handling, and storage.

4) The outside of the package or crate shall be adequately marked or tagged to indicate its contents by equipment name, contract name and number, and equipment number if applicable; approximate weight and pick-up points; state any special precautions for handling; and indicate the recommended requirements for storage prior to installation.

5) The manufacturer shall furnish one (1) set of any special wrenches and tools that may be required for assembly, disassembly, or adjustment.

6) Equipment weighing over 100 pounds shall be provided with lifting lugs or a recommended method of lifting the assembly with an overhead hoist.

B. Delivery:

1) Supplier shall deliver equipment by means of “Air-Ride” transportation, properly packaged in factory-fabricated containers and mounted on shipping skids. Include impact meters in component packages capable of recording "G's" attained by components during shipment. The equipment shall be wrapped and protected to prevent condensation inside the equipment during transportation.

2) Contractor will be responsible for unloading at the job site and installing the switchboards. A seven (7) day advance notice of delivery to the Owner’s representative is required followed by a twenty-four (24) hour notice prior to the expected delivery time at the designated location. Delivery will be accepted only during regular daytime work hours, Monday through Friday.

C. Storage and Handling:

1) Contractor shall store equipment in original packaging and protect from weather and construction traffic. Wherever possible, store indoors; where necessary to store outdoors, store above grade and enclose with watertight wrapping. The equipment shall be kept under controlled conditions to prevent moisture and/or condensation on critical parts.

2) Contractor shall handle equipment carefully to prevent physical damage to equipment and components. Remove packaging, including the opening of crates and containers, avoiding the use of excessive hammering and jarring which would damage the electrical equipment contained therein. Do not install damaged equipment; remove from site and replace damaged equipment with new.

7. MANUFACTURER'S SERVICES DURING CONSTRUCTION

A. Competent and experienced technical representatives shall represent the manufacturers of all equipment and systems as may be necessary to resolve assembly or installation problems, assist in testing, or perform start-up assistance at the work site that are attributable to, or associated with, the equipment furnished.

B. Where a manufacturer's certificate is called for in the Technical Specifications, a manufacturer's representative shall certify in writing stating that the equipment has been installed in accordance with the manufacturer's recommendation and has been inspected by a manufacturer's authorized representative, that it has been serviced with the proper initial lubricants, that applicable safety equipment has been properly installed and that the proper electrical and mechanical connections have been made.

8. FUNCTIONAL TESTING

A. The manufacturer's representative shall assist with the initial test. Initial equipment and system adjustment and calibrations shall be performed in the presence of, and with the assistance of the manufacturer's representative. The above-mentioned manufacturer's certification shall include the statement that proper adjustments have been made, and that the equipment or system is ready for plant start-up and operation.

9. SERVICES DURING PERFORMANCE TESTING AND PLANT START-UP

A. When technical assistance is necessary as a result of any malfunction of the equipment furnished, the manufacturer's representative shall provide such services. He shall also conduct and/or assist with final performance and demonstration testing, as required by the Specifications. These services shall continue until such times as the applicable equipment has been successfully performance tested and has been accepted by the Owner for full-time operation.

10. WARRANTY

A. As a minimum requirement, the Supplier shall guarantee, and so state in his Proposal, that the equipment furnished, including that furnished by him but supplied to him by others, is free from fault in design, workmanship, and material, and is of sufficient size and capacity, and is of proper material to fulfill satisfactorily the operating conditions specified. Should any defect in design, material, workmanship, or operating characteristics develop during the first 36 months of operations, but no later than 48 months after shipment form the Supplier's plant, the Supplier agrees to make all necessary or desirable alterations, repairs, and replacements of defective equipment, free of charge, and shall pay labor and transportation costs involved to and from the Owner's plant.

II. PART 2 - PRODUCTS

1. ACCEPTABLE MANUFACTURERS:

A. Square D Co.

B. Siemens

C. GE

D. Eaton (Cutler Hammer)

2. LOW VOLTAGE SWITCHGEAR

A. General:

1) Provide service entrance switchgear with switchboard style main and distribution sections.

2) Provide utility meter section per utility standards when indicated on the plans. The utility current transformer compartment shall comply with the local utility construction specifications.

3) Short Circuit Current Rating: Switchgears shall be rated with a minimum short circuit current rating as shown on plans.

4) Future Provisions: All unused spaces provided, unless otherwise specified, shall be fully equipped for future devices, including all appropriate connectors and mounting hardware.

5) Enclosure: Type 1 or Type 3R as indicated on the plans.

   a. Sections shall be aligned front and rear.

   b. Removable steel base channels (1.5 inch floor sills) shall be bolted to the frame to rigidly support the entire shipping section for moving on rollers and floor mounting.

   c. The Switchgear enclosure shall be painted on all exterior surfaces. The paint finish shall be a medium gray, ANSI #49, applied by the electro-deposition process over an iron phosphate pre-treatment.

   d. All front covers shall be screw removable with a single tool and all doors shall be hinged with removable hinge pins.

   e. Top and bottom conduit areas shall be clearly indicated on shop drawings.

6) Nameplates: Provide 1 inch high x 3 inches engraved laminated (Gravoply) nameplates for each device secured with rivets. Furnish black letters on a white background for all voltages.

7) Bus Composition: Shall be plated copper or aluminum. Plating shall be applied continuously to all bus work. The Switchgear bussing shall be of sufficient cross-sectional area to meet UL Standard 891 temperature rise requirements. The phase and neutral through-bus shall have an ampacity as shown in the plans. For 4-wire systems, the neutral shall be of equivalent ampacity as the phase bus bar. Tapered bus is not acceptable. Full provisions for the addition of future sections shall be provided. Bussing shall include all necessary hardware to accommodate splicing for future additions.

8) Ground Bus: Sized per NFPA70 and UL 891 Tables 25.1 and 25.2 and shall extend the entire length of the Switchgear. Provisions for the addition of future sections shall be provided.

9) Provide customer meter as indicated

10) Provide provisions for 3rd party SPD connection.

B. SWITCHGEAR - INCOMING MAIN SECTION DEVICES:

1) All lugs shall be UL Listed to accept solid and/or stranded copper and aluminum conductors. Lugs shall be suitable for 90° C rated wire, sized according to the 75° C temperature rating in the NEC. Provide mechanical type lugs to accommodate the conductors shown on the associated drawings.

C. SWITCHGEAR - DISTRIBUTION SECTION DEVICES

1) All unused spaces provided, unless otherwise specified, shall be fully equipped for future devices, including all appropriate connectors and mounting hardware

2) Electronic trip molded case full function 100% rated circuit breakers

- Provide 100% rated electronic trip circuit breakers when called for on the plans.
- Furnish thermal magnetic molded case circuit breakers for 250A frames and below.

3) Fused switches (when indicated on plans). Provide Class R fuses when available for the fuse size indicated.

4) Thermal magnetic molded case circuit breakers

- Molded case circuit breakers shall have integral thermal and instantaneous magnetic trip in each pole.
- Circuit protective devices shall be molded case circuit breaker(s). Circuit breaker(s) shall be standard interrupting, high interrupting, extra high interrupting or true current limiting as required by plans. Ampere ratings shall be as shown on the drawings.
- Manufacturer shall submit one set of published Ip and I^2t let-through curves (as required by UL) to the owner.

5) Factory Assembly and Tests: The Switchgear shall be completely assembled, wired, adjusted, and tested at the factory. After assembly, the complete Switchgear including circuit breakers shall be tested for operation under simulated service conditions to assure the accuracy of the wiring and the functioning of the equipment. The bus work, with all breakers connected and closed, shall be given a dielectric test of 2200V for one (1) minute between live parts and ground and between opposite polarities.

III. EXECUTION

1. GENERAL

A. Contractor shall install equipment described in this Specification, per manufacturer's recommended practice, as located on Drawings.

1) Contractor shall coordinate installation with manufacturer for start-up and certification.

2) Adjust breakers per Owner's representative's time-current coordination study.

3) Apply arc flash labeling provided by the Owner or his representative.

4) Contractor shall provide concrete pads for equipment. Comply with utility requirements for pad height when applicable.

2. FIELD START-UP SERVICE

A. Manufacturer shall provide the services of a competent Field Service Representative as needed to resolve any malfunctions and to make any inspections, checks, etc. needed to provide manufacturer's certification. A Manufacturer's Certification shall be provided prior to equipment being energized.

END OF SECTION

SECTION 26 23 13

EMERGENCY POWER SEQUENCE OF OPERATIONS

Refer to one-line diagrams, load calculations, and enlarged electrical room plans.
Refer to mechanical control specifications.

The emergency power plant is design to supply a Designated Critical Operations Area (DCOA) and associated Critical Operation Power Supply (COPS) as defined by NEC Art. 708. The COPS distribution equipment shall be fully selective as required by NEC Art. 708.

The emergency power plant as referred to in this document shall consist of three emergency diesel generators, one automatic transfer switch, distribution switchboards, emergency feeders, emergency panelboards, and associated controls equipment. The emergency feeders, communications, etc shall comply with requirements of NEC Art. 708 as they pertain to fire ratings and physical protection, in particular articles 708.14 and 708.10.

There is one utility source supplying the facility with dedicated service entrance section (SES) and dedicated interior electrical room for the associated normal and emergency electrical equipment.

There is one emergency power plant with three generators connected in parallel to a common emergency bus (DPG) located in electrical room. There is one automatic transfer switch and one emergency switchboard lineup located in the electrical room.

Each generator has a day tank with capacity rated for operation of the generators at design load for 72 hours.

The automatic transfer switch has an integral controller to control switching and communicate status and control to the Generator Main Control Panel (GMCP). The GMCP controls the generator paralleling, communicates with the individual generator controllers on each generator set, and acts as the generator remote annunciator. The generator controllers communicate to the BAS via BACNet. Status and alarms will be communicated to BAS and will include critical and non-critical alarms, generator fuel, battery status, etc. The auto transfer switch also communicates status of emergency and normal power to the 911 area via annunciator.

Generator airflow dampers are interlocked with generator operation (open when running) and are to fail open.

Generators shall be configured to be exercised weekly for 30 minutes without load and monthly for 30 minutes with temporary load bank.

Setpoints / Data:

ATS Set Points	Range	Setting*
Time Delay Engine Start (TDES)	(0-120sec)	0:01 seconds
ATS: Time Delay Normal to Emergency (TDNE)	(0-1800sec)	0:03 seconds
ATS: Time Delay Emergency to Normal (TDEN)	(0-1800sec)	4:00 minutes
Time Delay Engine Cool Off (TDEC)	(0-1800sec)	5:00 minutes
Time Delay Neutral (TDN)	(0-120sec)	0:00 seconds
Time Delay Emergency Fail	(0-6sec)	6 seconds
Time Delay to drop 3rd Generator (TD3G)	(0-1800sec)	5:00 minutes

GMCP Set Points	
High current setpoint #1 (1 generator running)	TBD
High high current setpoint #1 (1 generator running)	TBD
High current setpoint #2 (2 generators running)	TBD
High high current setpoint #2 (2 generators running)	TBD

* Final setpoints to be documented in contractor's SOO

Digital outputs:
Normal (NS) source available
Emergency (ES) source available

Load Priority Levels:
Priority Level #1: UPS systems, CRAC units, lighting, Critical group
Priority Level #2: Heater group A
Priority Level #3: Heater group B
Priority Level #4: Heater group C

Load Shed Sequence (in order of loads to be dropped):
1. During emergency operation / normal source failure
    a. Load bank
    b. Heater group C (interior zones, mechanical / electrical rooms)
    c. Heater group B (perimeter zones)
    d. Heater group A (CRAC heaters, board room heat)
    e. Critical group (based on facility operators direction as needed during one generator operation)

Facility conditions:

A. Condition #1 - Normal Operation:

* Normal Source supplies power to SES loads, normal and emergency.
* ATS is closed on Normal Source.
* Breakers in Paralleling Gear (DPG) are closed except Load Bank breaker is open.
* Breakers at Generators are open.
* Generators are not running.

B. Condition #2 - Failure of Normal Source

Upon a loss of normal source power at ATS

- The pre-set time delay (TDES) in ATS shall begin
- An alarm, Loss of Normal Source shall be sent to GMCP.
- The GMCP (via output relay) shall trip the Load Bank breaker upon expiration of TDES.
- ATS shall send start signal to the generator main control panel (GMCP) after the respective time delay TDES reaches zero.
- The GMCP shall send start signal to the three Generators #1, #2, and #3 (GEN-1, GEN-2, and GEN-3)
- [The Generator Exhaust Dampers interlocked with the Generator shall open upon the Generator starting.]
- The first generator to reach rated frequency and voltage connects to the generator paralleling bus DPG via normally closed breaker in DPG by closure of breaker at the corresponding generator.
- ATS (Normal Source), "Emergency Source Available" shall illuminate.
- Status signals from ATS, "Emergency Position" indication shall be sent to GMCP.
- The second generator, upon synchronizing, connects to the paralleling gear (DPG). There is now sufficient generator capacity to energize the remaining ATS loads.
- The third generator, upon synchronizing, connects to the generator paralleling gear. Note: All 3 generators will start and connect to paralleling gear regardless of initial load conditions. Upon 3 generators running for a pre-set time delay (TD3G) the loading will be checked at the GMCP. If loading is below [high current setpoint #2] one of the 3 generators will disconnect from the paralleling gear and shut down. Otherwise, the 3 generators will continue to run.
    - The 3rd generator will be assigned based on a rotating sequence. Should one of the other two generators fail during operation, the third generator shall be started and connected to the paralleling gear.
- Generators shall operate continuously.
    - Should the load on generators exceed the high limit [high current setpoint #1] when (2) generators are running, the third generator shall start and connect to the bus.
    - Should the load on generators exceed the high high limit [high high current setpoint #2] when (3) generators are running, a High Load Alarm shall be sent to the BAS as a discrete output from GMCP instructing the BAS to prevent specific heater groups from operating.
- ATS, upon the pre-set time delay (TDNE) reaching zero and receiving a permissive transfer signal from GMCP confirming that DPG is being supplied by at least two generators, transfers from normal position to the emergency position connecting to the paralleling gear (DPG).
- Status signals from ATS, "Emergency Position" indication shall be sent to GMCP.
- If one of the two generators were to fail, the ATS shall be prevented from closing to the emergency source until the third generator comes online and synchronizes to DPG.
- The emergency source DPG shall provide power to ATS continuously operating in Condition #2 until one of the following.
    - Return of Normal Source (NS). Upon return of NS the ATS sends a signal to GMCP that NS is available, "Normal (NS) Source Available".
        - ATS will transfer from emergency to normal after their respective time delay (TDEN), which is the time to verify that the normal source is stable before the ATS will transfer from emergency to normal, will transfer back to normal source NS.

- For ATS “Normal Position” is illuminated and “Emergency Position” is extinguished.
- After transfer switch has transferred, the cool down time delay (TDEC) shall start. After cool down time delay (TDEC), all generators will disconnect from DPG and shut down.
- System has now returned to Condition #1.

E. Condition #3 - Failure of more than one generator (i.e. only one generator connected)

Upon failure of two generators to start (via generator fault alarms or lack of generator connected status signals), the GMCP shall shed loads in order of priority. If high high current alarm #1 setpoint is reached, an alarm is sent to BAS and facility operator may select from critical loads to shutdown to reduce load to acceptable levels to maintain generator operation

G. Condition #4 – Test Generators using Temporary Load Bank

Confirm system is operating under normal conditions, Condition #1. Confirm Load Bank breaker in Paralleling Gear (DPG) is open.

Connect load bank to temporary load bank lug box.

Manually initiate generator start via Generator Main Control Panel (GMCP) for the desired number of generators.

When generators have synchronized and closed to the Paralleling Gear (DPG), manually close load bank breaker in Paralleling Gear (DPG) and proceed with load bank testing.

Upon completion of tests open load bank breaker, disconnect load bank, and initiate generator shut down timer.

SECTION 26 24 13

SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Section 26 43 13 Surge Protection Devices for Low Voltage Electrical Power Circuits

1.2 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Transient voltage suppression devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.
7. Identification.
8. Mimic bus.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.4 ACTION SUBMITTALS

A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.

5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
6. Detail utility company's metering provisions with indication of approval by utility company.
7. Include evidence of NRTL listing for series rating of installed devices.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
10. Include diagram and details of proposed mimic bus.
11. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Samples: Representative portion of mimic bus with specified material and finish, for color selection.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for switchboards and all installed components.
2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
4. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
6. Indicating Lights: Equal to 10 percent of quantity installed for each size and type, but no fewer than one of each size and type.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

C. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Comply with NEMA PB 2.

G. Comply with NFPA 70.

H. Comply with UL 891.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards and [install temporary electric heating (250 W per section)] [connect factory-installed space heaters to temporary electrical service] to prevent condensation.

C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.10 PROJECT CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Not exceeding 104 deg F.
    b. Altitude: Not exceeding 6600 feet.

C. Service Conditions: NEMA PB 2, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet.

D. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager no fewer than days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Construction Manager's written permission.
4. Comply with NFPA 70E.

1.11 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.12 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit. (Basis of design)

2. Square D; a brand of Schneider Electric.

3. Siemens

4. GE

C. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

D. Front- and Side-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

E. Front- and Rear-Accessible Switchboards:

1. Main Devices: Drawout mounted.
2. Branch Devices: Individually compartmented and drawout mounted.
3. Sections front and rear aligned.

F. Nominal System Voltage: 480Y/277 V, 208Y/120 V.

G. Main-Bus Continuous: A indicated on plans.

H. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."

I. Indoor Enclosures: Steel, NEMA 250, Type 1.

J. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

K. Outdoor Enclosures: Type 3R.

1. Finish: Factory-applied finish in manufacturer's standard color; undersurfaces treated with corrosion-resistant undercoating.
2. Enclosure: Flat roof; for each section, with provisions for padlocking.
3. Doors: Personnel door at each end of aisle, minimum width of 30 inches; opening outwards; with panic hardware and provisions for padlocking.
4. Accessories: Fluorescent lighting fixtures, ceiling mounted; wired to a three-way light switch at each end of aisle; ground-fault circuit interrupter (GFCI) duplex receptacle; emergency battery pack lighting fixture installed on wall of aisle midway between personnel doors.
5. Walk-in Aisle Heating and Ventilating:

    a. Factory-installed electric unit heater(s), wall or ceiling mounted, with integral thermostat and disconnect and with capacities to maintain switchboard interior temperature of 40 deg F with outside design temperature of.
    b. Factory-installed exhaust fan with capacities to maintain switchboard interior temperature of 100 deg F with outside design temperature of 23 deg F.
    c. Ventilating openings.
    d. Thermostat: Single stage; wired to control heat and exhaust fan.

6. Power for Space Heaters, Ventilation, Lighting, and Receptacle: Include a control-power transformer within the switchboard. Supply voltage shall be 120-V ac.
7. Power for space heaters, ventilation, lighting, and receptacle provided by a remote source.

L. Barriers: Between adjacent switchboard sections.

M. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

N. Cubical Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.

1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point.
2. Space-Heater Power Source: Transformer, factory installed in switchboard.

O. Utility Metering Compartment: Fabricated, barrier compartment and section complying with utility company's requirements; hinged sealed door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

P. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.

Q. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

R. Removable, Hinged Rear Doors and Compartment Covers: Secured by standard bolts, for access to rear interior of switchboard.

S. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

T. Pull Box on Top of Switchboard:

1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
2. Set back from front to clear circuit-breaker removal mechanism.
3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

U. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity,with tin-plated aluminum or copper feeder circuit-breaker line connections.
2. Phase- and Neutral-Bus Material: Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
3. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.
4. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
5. Ground Bus: 1/4-by-2-inch- hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
6. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
7. Neutral Buses: 50 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
8. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
9. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

V. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

W. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of .

X. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

2.2 SURGE PROTECTION DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit. (Basis of design)

2. Square D; a brand of Schneider Electric.

3. Siemens

4. GE

C. Surge Protection Device Description: IEEE C62.41-compliant, integrally mounted, wired-in, solid-state, parallel-connected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the switchboard short-circuit rating, and with the following features and accessories:

1. Fuses, rated at 200-kA interrupting capacity.
2. Fabrication using bolted compression lugs for internal wiring.
3. Integral disconnect switch.
4. Redundant suppression circuits.
5. Redundant replaceable modules.
6. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
7. LED indicator lights for power and protection status.
8. Audible alarm, with silencing switch, to indicate when protection has failed.
9. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
10. Six-digit, transient-event counter set to totalize transient surges.

D. Peak Single-Impulse Surge Current Rating: [160 kA per mode/320 kA per phase] [120 kA per mode/240 kA per phase] [80 kA per mode/160 kA per phase].

E. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.

F. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277-V, three-phase, four-wire circuits shall be as follows:

1. Line to Neutral: 800 V for 480Y/277.
2. Line to Ground: 800 V for 480Y/277.
3. Neutral to Ground: 800 V for 480Y/277.

G. Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:

1. Line to Neutral: 400 V, 800 V from high leg.
2. Line to Ground: 400 V.
3. Neutral to Ground: 400 V.

H. Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:

1. Line to Line: 2000 V for 480 V.
2. Line to Ground: 1500 V for 480 V.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

    a. Instantaneous trip.
    b. Long- and short-time pickup levels.
    c. Long- and short-time time adjustments.
    d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
6. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.
    b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
    c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
    d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
    f. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Section 26 09 13 "Electrical Power Monitoring and Control."
    g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at [**55**] [**75**] percent of rated voltage.
    h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
    i. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

B. Insulated-Case Circuit Breaker (ICCB): 100 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.

1. Fixed circuit-breaker mounting.
2. Two-step, stored-energy closing.
3. Full-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:

   a. Instantaneous trip.
   b. Long- and short-time time adjustments.
   c. Ground-fault pickup level, time delay, and I^2t response.

4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
5. Remote trip indication and control.
6. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Section 26 09 13 "Electrical Power Monitoring and Control."
7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
8. Control Voltage: 120-V ac.

C. Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on the switch blade after it engages the stationary contacts.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton Electrical Inc.; Cutler-Hammer Business Unit. (Basis of design)
   b. Square D; a brand of Schneider Electric.
   c. Siemens
   d. GE

2. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
3. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.

   a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
   b. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.

4. Auxiliary Switches: Factory installed, single pole, double throw, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
5. Service-Rated Switches: Labeled for use as service equipment.
6. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.

   a. Configuration: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

b. Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.
c. No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.
d. Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).

7. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

D. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

E. Fuses are specified in Section 26 28 13 "Fuses."

2.4 INSTRUMENTATION

A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:

1. Potential Transformers: IEEE C57.13; 120 V, 60 Hz, single secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; wound type; [**double**] secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:

a. Phase Currents, Each Phase: Plus or minus 1 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
d. Megawatts: Plus or minus 2 percent.
e. Megavars: Plus or minus 2 percent.
f. Power Factor: Plus or minus 2 percent.
g. Frequency: Plus or minus 0.5 percent.
h. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
i. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.
j. Contact devices to operate remote impulse-totalizing demand meter.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

C. Ammeters, Voltmeters, and Power-Factor Meters: ANSI C39.1.

1. Meters: 4-inch diameter or 6 inches square, flush or semiflush, with antiparallax 250-degree scales and external zero adjustment.
2. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.

D. Instrument Switches: Rotary type with off position.

1. Voltmeter Switches: Permit reading of all phase-to-phase voltages and, where a neutral is indicated, phase-to-neutral voltages.
2. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.

E. Feeder Ammeters: 2-1/2-inch minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for indicated feeder circuits only.

F. Watt-Hour Meters and Wattmeters:

1. Comply with ANSI C12.1.
2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
3. Suitable for connection to three- and four-wire circuits.
4. Potential indicating lamps.
5. Adjustments for light and full load, phase balance, and power factor.
6. Four-dial clock register.
7. Integral demand indicator.
8. Contact devices to operate remote impulse-totalizing demand meter.
9. Ratchets to prevent reverse rotation.
10. Removable meter with drawout test plug.
11. Semiflush mounted case with matching cover.
12. Appropriate multiplier tag.

G. Impulse-Totalizing Demand Meter:

1. Comply with ANSI C12.1.
2. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.
3. Cyclometer.
4. Four-dial, totalizing kilowatt-hour register.
5. Positive chart drive mechanism.
6. Capillary pen holding a minimum of one month's ink supply.
7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
8. Capable of indicating and recording [**five**] [**15**] [**30**] <**Insert time period**>-minute integrated demand of totalized system.

2.5 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Control Circuits: 120-V ac, supplied from remote branch circuit.

C. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.

D. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

E. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.6 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

C. Portable Circuit-Breaker Lifting Device: Floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.

D. Overhead Circuit-Breaker Lifting Device: Mounted at top front of switchboard, with hoist and lifting yokes matching each drawout circuit breaker.

E. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

2.7 IDENTIFICATION

A. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on a photoengraved nameplate.

1. Nameplate: At least 0.032-inch- thick anodized aluminum, located at eye level on front cover of the switchboard incoming service section.

B. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on an engraved laminated-plastic (Gravoply) nameplate.

1. Nameplate: At least 0.0625-inch- thick laminated plastic (Gravoply), located at eye level on front cover of the switchboard incoming service section.

C. Mimic Bus: Continuously integrated mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram.

D. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.

E. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.

F. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Section 03 30 00 "Cast-in-Place Concrete." Section 03 30 53 "Miscellaneous Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to switchboards.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements specified in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."

E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

F. Install filler plates in unused spaces of panel-mounted sections.

G. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.

1. Set field-adjustable switches and circuit-breaker trip ranges.

H. Install spare-fuse cabinet.

I. Comply with NECA 1.

3.3 CONNECTIONS

A. Comply with requirements for terminating feeder bus specified in Section 26 25 00 "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.

B. Comply with requirements for terminating cable trays specified in Section 26 05 36 "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Acceptance Testing Preparation:

1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

E. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
c. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Switchboard will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges [as indicated.] [as specified in Section 26 05 73.16 "Overcurrent Protective Device Coordination Study."]

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

END OF SECTION

SECTION 26 24 16

PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Load centers.
4. Electronic-grade panelboards.

1.3 DEFINITIONS

A. SVR: Suppressed voltage rating.

B. TVSS: Transient voltage surge suppressor.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Include evidence of NRTL listing for series rating of installed devices.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include wiring diagrams for power, signal, and control wiring.
8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: Two spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.
3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NEMA PB 1.

F. Comply with NFPA 70.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.10 PROJECT CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.
b. Altitude: Not exceeding 6600 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet.

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager no fewer than two days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Construction Manager's written permission.
3. Comply with NFPA 70E.

1.11 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.12 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."

B. Enclosures: Flush- and surface-mounted cabinets.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
b. Outdoor Locations: NEMA 250, Type 3R.
c. Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
6. Finishes:

a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
b. Back Boxes: Galvanized steel.

c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

7. Directory Card: Inside panelboard door, mounted in transparent card holder.

C. Incoming Mains Location: Top and bottom.

D. Phase, Neutral, and Ground Buses:

1. Material: Tin-plated aluminum.
2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
3. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
4. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
5. Split Bus: Vertical buses divided into individual vertical sections.

E. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Tin-plated aluminum.
2. Main and Neutral Lugs: Mechanical type.
3. Ground Lugs and Bus-Configured Terminators: Mechanical type.
4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
5. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
6. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
7. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.

G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

H. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include size and type of allowable upstream and branch devices, listed and labeled for series-connected short-circuit rating by an NRTL.

I. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 1.

2.3 DISTRIBUTION PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit. (Basis of design)
2. Square D; a brand of Schneider Electric.
3. Siemens
4. GE

C. Panelboards: NEMA PB 1, power and feeder distribution type.

D. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches high, provide two latches, keyed alike.

E. Mains: As indicated on plans.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

G. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

H. Branch Overcurrent Protective Devices: Fused switches.

I. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
2. External Control-Power Source: 120-V branch circuit.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit. (Basis of design)

2. Square D; a brand of Schneider Electric.

3. Siemens

4. GE

C. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

D. Mains: As indicated on plans.

E. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

F. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
2. External Control-Power Source: 120-V branch circuit.

G. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

H. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit. (Basis of design)

2. Square D; a brand of Schneider Electric.

3. Siemens

4. GE

C. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

a. Instantaneous trip.
b. Long- and short-time pickup levels.

c. Long- and short-time time adjustments.
d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
6. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
7. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
e. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Section 26 09 13 "Electrical Power Monitoring and Control."
f. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
g. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
h. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
i. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
k. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
l. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
m. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
n. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

D. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

1. Fuses, and Spare-Fuse Cabinet: Comply with requirements specified in Section 26 28 13 "Fuses."
2. Fused Switch Features and Accessories: Standard ampere ratings and number of poles.
3. Auxiliary Contacts: One normally open and normally closed contact(s) that operate with switch handle operation.

2.6 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Equipment Mounting: Install panelboards on concrete bases, 4-inch nominal thickness. Comply with requirements for concrete base specified in Section 03 30 00 "Cast-in-Place Concrete." Section 03 30 53 "Miscellaneous Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
2. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to panelboards.
5. Attach panelboard to the vertical finished or structural surface behind the panelboard.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

D. Comply with mounting and anchoring requirements specified in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."

E. Mount top of trim 90 inches above finished floor unless otherwise indicated.

F. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

G. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

H. Install filler plates in unused spaces.

I. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

J. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

K. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 26 05 53 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

E. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
c. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

F. Panelboards will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as provided by Engineer of Supplier's time-current coordination study approved by the Engineer.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.

1. Measure as directed during period of normal system loading.
2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.6 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION

SECTION 26 27 26

WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Twist-locking receptacles.
3. Receptacles with integral surge-suppression units.
4. Isolated-ground receptacles.
5. Hospital-grade receptacles.
6. Tamper-resistant receptacles.
7. Weather-resistant receptacles.
8. Snap switches and wall-box dimmers.
9. Solid-state fan speed controls.
10. Wall-switch and exterior occupancy sensors.
11. Communications outlets.
12. Pendant cord-connector devices.
13. Cord and plug sets.
14. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. TVSS: Transient voltage surge suppressor.

F. UTP: Unshielded twisted pair.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Service/Power Poles: One for every 10, but no fewer than one.
2. Floor Service-Outlet Assemblies: One for every 10, but no fewer than one.
3. Poke-Through, Fire-Rated Closure Plugs: One for every five floor service outlets installed, but no fewer than two.
4. TVSS Receptacles: One for every 10 of each type installed, but no fewer than two of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

1. Cooper Wiring Devices; Division of Cooper Industries, Inc. (Cooper).

2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).

3. Leviton Mfg. Company Inc. (Leviton).

4. Pass & Seymour/Legrand (Pass & Seymour).

B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with the requirements in this Section.

2.3 STRAIGHT-BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; 5351 (single), CR5362 (duplex).

b. Hubbell; HBL5351 (single), HBL5352 (duplex).

c. Leviton; 5891 (single), 5352 (duplex).

d. Pass & Seymour; 5361 (single), 5362 (duplex).

B. Hospital-Grade, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498 Supplement sd, and FS W-C-596.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; 8310 (single), 8300 (duplex).

b. Hubbell; HBL8310 (single), HBL8300 (duplex).

c. Leviton; 8310 (single), 8300 (duplex).

d. Pass & Seymour; 8301 (single), 8300H (duplex).

2. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap.

C. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; IG5362RN.

b. Hubbell; IG5362.

c. Leviton; 5362-IG.

d. Pass & Seymour; IG5362.

2. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

D. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498 Supplement sd, and FS W-C-596.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; TR8300.

b. Hubbell; HBL8300SGA.

c. Leviton; 8300-SGG.

d. Pass & Seymour; TR63H.

2. Description: Labeled shall comply with NFPA 70, "Health Care Facilities" Article, "Pediatric Locations" Section.

2.4 GFCI RECEPTACLES

A. General Description:

1. Straight blade, feed-through type.
2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; VGF20.

b. Hubbell; GFR5352L.

c. Pass & Seymour; 2095.

d. Leviton; 7590.

C. Tamper-Resistant GFCI Convenience Receptacles, 125 V, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Hubbell; GFTR20.

b. Pass & Seymour; 2095TR.

D. Hospital-Grade, Duplex GFCI Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498 Supplement sd, and FS W-C-596.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; VGFH20.

b. Hubbell; HFR8300HL.

c. Leviton; 7899-HG.

d. Pass & Seymour; 2095HG.

2.5 TVSS RECEPTACLES

A. General Description: Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 1449, and FS W-C-596, with integral TVSS in line to ground, line to neutral, and neutral to ground.

1. TVSS Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 V and minimum single transient pulse energy dissipation of 240 J, according to IEEE C62.41.2 and IEEE C62.45.
2. Active TVSS Indication: Visual and audible, with light visible in face of device to indicate device is "active" or "no longer in service."

B. Duplex TVSS Convenience Receptacles:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; 5362BLS.

b. Hubbell; HBL5362SA.

c. Leviton; 5380.

d. Pass & Seymour; 5362BLSP.

2. Description: Straight blade, 125 V, 20 A; NEMA WD 6 Configuration 5-20R.

C. Isolated-Ground, Duplex Convenience Receptacles:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; IG5362BLS.

b. Hubbell; IG5362SA.

c. Leviton; 5380-IG.

d. Pass & Seymour; IG5362BLSP.

2. Description:

a. Straight blade, 125 V, 20 A; NEMA WD 6 Configuration 5-20R.
b. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

D. Hospital-Grade, Duplex Convenience Receptacles: Comply with UL 498 Supplement sd.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; 8300BLS.

b. Hubbell; HBL8362SA.

c. Leviton; 8380.

d. Pass & Seymour; 8300BLSP.

2. Description: Straight blade, 125 V, 20 A; NEMA WD 6 Configuration 5-20R.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Comply with NFPA 70.

E. Isolated-Ground, Hospital-Grade, Duplex Convenience Receptacles:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; IG8300HGBLS.

b. Hubbell; IG8362SA.

c. Leviton; 8380-IG.

d. Pass & Seymour; IG8300BLSP.

2. Description:

a. Straight blade, 125 V, 20 A; NEMA WD 6 Configuration 5-20R.
b. Comply with UL 498 Supplement sd.
c. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.6 HAZARDOUS (CLASSIFIED) LOCATION RECEPTACLES

A. Wiring Devices for Hazardous (Classified) Locations: Comply with NEMA FB 11 and UL 1010.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Cooper Crouse-Hinds.

b. EGS/Appleton Electric.

c. Killark; Division of Hubbell Inc.

2.7 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; CWL520R.

b. Hubbell; HBL2310.

c. Leviton; 2310.

d. Pass & Seymour; L520-R.

B. Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; IGL520R.

b. Hubbell; IG2310.

c. Leviton; 2310-IG.

d. Pass & Seymour; IG4700.

2. Description:

a. Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.
b. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.8 PENDANT CORD-CONNECTOR DEVICES

A. Description:

1. Matching, locking-type plug and receptacle body connector.
2. NEMA WD 6 Configurations L5-20P and L5-20R, heavy-duty grade, and FS W-C-596.
3. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.
4. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.9 CORD AND PLUG SETS

A. Description:

1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.10 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120/277 V, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:

1) Single Pole:

2) Cooper; AH1221.
3) Hubbell; HBL1221.

4) Leviton; 1221-2.

5) Pass & Seymour; CSB20AC1.
6) Two Pole:

7) Cooper; AH1222.
8) Hubbell; HBL1222.

9) Leviton; 1222-2.

10) Pass & Seymour; CSB20AC2.
11) Three Way:

12) Cooper; AH1223.
13) Hubbell; HBL1223.

14) Leviton; 1223-2.

15) Pass & Seymour; CSB20AC3.
16) Four Way:

17) Cooper; AH1224.
18) Hubbell; HBL1224.

19) Leviton; 1224-2.

20) Pass & Seymour; CSB20AC4.

C. Pilot-Light Switches, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Cooper; AH1221PL for 120 and 277 V.

    b. Hubbell; HBL1201PL for 120 and 277 V.

    c. Leviton; 1221-LH1.

    d. Pass & Seymour; PS20AC1RPL for 120 V, PS20AC1RPL7 for 277 V.

2. Description: Single pole, with neon-lighted handle, illuminated when switch is "off."

D. Key-Operated Switches, 120/277 V, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Cooper; AH1221L.

    b. Hubbell; HBL1221L.

    c. Leviton; 1221-2L.

    d. Pass & Seymour; PS20AC1-L.

2. Description: Single pole, with factory-supplied key in lieu of switch handle.

E. Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches: 120/277 V, 20 A; for use with mechanically held lighting contactors.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Cooper; 1995.

    b. Hubbell; HBL1557.

    c. Leviton; 1257.

    d. Pass & Seymour; 1251.

F. Key-Operated, Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches: 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Cooper; 1995L.

    b. Hubbell; HBL1557L.

    c. Leviton; 1257L.

    d. Pass & Seymour; 1251L.

2.11 DECORATOR-STYLE DEVICES

A. Convenience Receptacles: Square face, 125 V, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, and UL 498.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; 6252.

b. Hubbell; DR15.

c. Leviton; 16252.

d. Pass & Seymour; 26252.

B. Tamper-Resistant Convenience Receptacles: Square face, 125 V, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, and UL 498.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; TR6252.

b. Hubbell; DR15TR.

c. Pass & Seymour; TR26252.

2. Description: Labeled to comply with NFPA 70, "Receptacles, Cord Connectors, and Attachment Plugs (Caps)" Article, "Tamper-Resistant Receptacles in Dwelling Units" Section.

C. Tamper-Resistant and Weather-Resistant Convenience Receptacles: Square face, 125 V, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, and UL 498.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; TWRBR15.

b. Hubbell; DR15TR.

c. LevitonTRW15.

d. Pass & Seymour; TRW26252.

2. Description: Labeled to comply with NFPA 70, "Receptacles, Cord Connectors, and Attachment Plugs (Caps)" Article, "Tamper-Resistant Receptacles in Dwelling Units" Section, when installed in wet and damp locations.

D. GFCI, Feed-Through Type, Convenience Receptacles: Square face, 125 V, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, UL 498, and UL 943 Class A.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; VGF15.

b. Hubbell; GF15LA.

c. Leviton; 8599.

d. Pass & Seymour; 1594.

E. GFCI, Tamper-Resistant and Weather-Resistant Convenience Receptacles: Square face, 125 V, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, UL 498, and UL 943 Class A.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; TWRVGF15.

b. Hubbell; GFTR15.

c. Pass & Seymour; 1594TRWR.

2. Description: Labeled to comply with NFPA 70, "Receptacles, Cord Connectors, and Attachment Plugs (Caps)" Article, "Tamper-Resistant Receptacles in Dwelling Units" Section.

F. Toggle Switches, Square Face, 120/277 V, 15 A: Comply with NEMA WD 1, UL 20, and FS W-S-896.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; 7621 (single pole), 7623 (three way).

b. Hubbell; DS115 (single pole), DS315 (three way).

c. Leviton; 5621-2 (single pole), 5623-2 (three way).

d. Pass & Seymour; 2621 (single pole), 2623 (three way).

G. Lighted Toggle Switches, Square Face, 120 V, 15 A: Comply with NEMA WD 1 and UL 20.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; 7631 (single pole), 7633 (three way).

b. Hubbell; DS120IL (single pole), DS320 (three way).

c. Leviton; 5631-2 (single pole), 5633-2 (three way).

d. Pass & Seymour; 2625 (single pole), 2626 (three way).

2. Description: With neon-lighted handle, illuminated when switch is "off."

2.12 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 0.035-inch- thick, satin-finished, Type 302 stainless steel.
3. Material for Unfinished Spaces: Smooth, high-impact thermoplastic.

4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.13 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: Rectangular, solid brass with satin finish.

D. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.

E. Voice and Data Communication Outlet: Blank cover with bushed cable opening

2.14 PREFABRICATED MULTIOUTLET ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Universal Electric Corp. (Starline)

2. Mono-Systems SWA4800 Series 2 Compartment Aluminum Raceway, 6” x 2.3”

3. Hubbell Incorporated; Wiring Device-Kellems.

4. Wiremold/Legrand G3000 Series.

C. Description:

1. Two-piece surface metal raceway, with factory-wired multioutlet harness.
2. Components shall be products from single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

D. Raceway Material: Metal, with manufacturer's standard finish.

E. Multioutlet Harness:

1. Receptacles: 15-A, 125-V, NEMA WD 6 Configuration 5-15R receptacles complying with NEMA WD 1, UL 498, and FS W-C-596.
2. Receptacle Spacing: 18 inches.
3. Wiring: No. 12 AWG solid, Type THHN copper, single circuit.

2.15 SERVICE POLES

A. Description:

1. Factory-assembled and -wired units to extend power and voice and data communication from distribution wiring concealed in ceiling to devices or outlets in pole near floor.
2. Poles: Nominal 2.5-inch- square cross section, with height adequate to extend from floor to at least 6 inches above ceiling, and with separate channels for power wiring and voice and data communication cabling.
3. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.
4. Finishes: Manufacturer's standard painted finish and trim combination.
5. Wiring: Sized for minimum of five No. 12 AWG power and ground conductors and a minimum of four, four-pair, Category 3 or Category 5 voice and data communication cables.
6. Power Receptacles: Two duplex, 20-A, straight-blade receptacles complying with requirements in this Section.
7. Voice and Data Communication Outlets: Blank insert with bushed cable opening complying with requirements in Section 27 15 00 "Communications Horizontal Cabling."

2.16 FINISHES

A. Device Color:

1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Power System: Red.
3. TVSS Devices: Blue.
4. Isolated-Ground Receptacles: Orange.

B. Wall Plate Color: For plastic covers, match device color.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.

2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

    a. Cut back and pigtail, or replace all damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the left.
2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

A. Comply with Section 26 05 53 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. In healthcare facilities, prepare reports that comply with recommendations in NFPA 99.
2. Test Instruments: Use instruments that comply with UL 1436.
3. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Test straight-blade convenience outlets in patient-care areas for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz..

D. Wiring device will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION

SECTION 26 28 13

FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600-V ac and less for use in enclosed switches, enclosed controllers, and motor-control centers.
2. Plug fuses rated 125-V ac and less for use in plug-fuse-type enclosed switches fuseholders and panelboards.
3. Plug-fuse adapters for use in Edison-base, plug-fuse sockets.
4. Spare-fuse cabinets.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

    a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
    b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
3. Current-limitation curves for fuses with current-limiting characteristics.
4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
5. Coordination charts and tables and related data.
6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
4. Coordination charts and tables and related data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Comply with UL 248-11 for plug fuses.

1.7 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.8 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper Bussmann, Inc.

2. Edison Fuse, Inc.

3. Ferraz Shawmut, Inc.

4. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

2.3 PLUG FUSES

A. Characteristics: UL 248-11, nonrenewable plug fuses; 125-V ac.

2.4 PLUG-FUSE ADAPTERS

A. Characteristics: Adapters for using Type S, rejection-base plug fuses in Edison-base fuseholders or sockets; ampere ratings matching fuse ratings; irremovable once installed.

2.5 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch- high letters on exterior of door.
4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

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

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Service Entrance: Class RK1, time delay.
2. Feeders: Class RK1, time delay.
3. Motor Branch Circuits: Class RK5, time delay.
4. Other Branch Circuits: Class RK5, time delay.
5. Control Circuits: Class CC, fast acting.

B. Plug Fuses:

1. Motor Branch Circuits: Edison-base type, dual-element time delay.
2. Other Branch Circuits: Edison-base type, dual-element time delay.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install plug-fuse adapters in Edison-base fuseholders and sockets. Ensure that adapters are irremovable once installed.

C. Install spare-fuse cabinet(s).

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION

SECTION 26 28 16

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Receptacle switches.
4. Shunt trip switches.
5. Molded-case circuit breakers (MCCBs).
6. Molded-case switches.
7. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.5 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).

4. Include evidence of NRTL listing for series rating of installed devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Manufacturer's field service report.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Fuse Pullers: Two for each size and type.

1.9 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NFPA 70.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without [**Architect's**] Construction Manager's written permission.
4. Comply with NFPA 70E.

1.11 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit. (Basis of Design)
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

C. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

E. Type HD, Heavy Duty, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

F. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Mechanical type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

2.2 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit. (Basis of Design)

2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

3. Siemens Energy & Automation, Inc.

4. Square D; a brand of Schneider Electric.

C. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

E. Type HD, Heavy Duty, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

F. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
4. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
5. Hookstick Handle: Allows use of a hookstick to operate the handle.
6. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.3 RECEPTACLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

3. Siemens Energy & Automation, Inc.

4. Square D; a brand of Schneider Electric.

C. Type HD, Heavy-Duty, Single-Throw Fusible Switch: 600-V ac, 30 60 100 A; UL 98 and NEMA KS 1; horsepower rated, with clips or bolt pads to accommodate specified fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

D. Type HD, Heavy-Duty, Single-Throw Nonfusible Switch: 600-V ac, 30 60 100 A; UL 98 and NEMA KS 1; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

E. Interlocking Linkage: Provided between the receptacle and switch mechanism to prevent inserting or removing plug while switch is in the on position, inserting any plug other than specified, and turning switch on if an incorrect plug is inserted or correct plug has not been fully inserted into the receptacle.

F. Receptacle: Polarized, three-phase, four-wire receptacle (fourth wire connected to enclosure ground lug).

2.4 SHUNT TRIP SWITCHES

A. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Cooper Bussmann, Inc.
2. Ferraz Shawmut, Inc.
3. Littelfuse, Inc.

C. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with 200-kA interrupting and short-circuit current rating when fitted with Class J fuses.

D. Switches: Three-pole, horsepower rated, with integral shunt trip mechanism and Class J fuse block; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

E. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power transformer of enough capacity to operate shunt trip, connected pilot, and indicating and control devices.

F. Accessories:

1. Oiltight key switch for key-to-test function.
2. Oiltight green ON pilot light.
3. Isolated neutral lug; 100 percent rating.
4. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
5. Form C alarm contacts that change state when switch is tripped.
6. Three-pole, double-throw, fire-safety and alarm relay; 120-V ac coil voltage.
7. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.

2.5 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

C. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

D. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

E. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

F. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I^2t response.

G. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

H. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.

I. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

J. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

K. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.

4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
5. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system, specified in Section 26 09 13 "Electrical Power Monitoring and Control."
6. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
7. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
8. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
9. Alarm Switch: One NO NC contact that operates only when circuit breaker has tripped.
10. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
11. Zone-Selective Interlocking: Integral with electronic ground-fault trip unit; for interlocking ground-fault protection function.
12. Electrical Operator: Provide remote control for on, off, and reset operations.
13. Accessory Control Power Voltage: Integrally mounted, self-powered;.

2.6 MOLDED-CASE SWITCHES

A. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

3. Siemens Energy & Automation, Inc.

4. Square D; a brand of Schneider Electric.

C. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

D. Features and Accessories:

1. Standard frame sizes and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
6. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
7. Alarm Switch: One NO contact that operates only when switch has tripped.

8. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
9. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
10. Electrical Operator: Provide remote control for on, off, and reset operations.
11. Accessory Control Power Voltage: Integrally mounted, self-powered;.

2.7 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
6. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7 Type 9.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Comply with mounting and anchoring requirements specified in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

E. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges[as specified in Section 26 05 73.16 "Overcurrent Protective Device Coordination Study."]

END OF SECTION

SECTION 26 32 13

ENGINE GENERATORS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The generator plant to be installed shall consist of (3) diesel generator sets, open type, skid mounted with off-package paralleling, master system controller, associated control devices, wiring, etc. for a complete and operational system with the intent of the drawings and specifications.

1.2 RELATED DOCUMENTS

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

B. Section 26 23 13 Emergency Power Sequence of Operations

1.3 SUMMARY

A. This Section includes packaged engine-generator sets for emergency power supply with the following features:

1. Diesel engine with off-package paralleling controls for multiple (N+1) generator arrangement.
2. Sub base fuel tanks, UL 142.
3. Unit-mounted cooling system.
4. Unit-mounted control and monitoring.
5. Performance requirements for sensitive loads.
6. Open enclosures, installed indoors.

B. Related Sections include the following:

1. Section 26 36 00 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

1.4 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:

1. Thermal damage curve for generator.
2. Time-current characteristic curves for generator protective device.

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. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
4. Wiring Diagrams: Power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Manufacturer Seismic Qualification Certification: Submit certification that fuel tank, engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces defined in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event"

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Qualification Data: For manufacturer.

C. Source quality-control test reports.

1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report of sound generation.

6. Report of exhaust emissions showing compliance with applicable regulations.
7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

D. Field quality-control test reports.

E. Warranty: Special warranty specified in this Section.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

1. Maintenance Proximity: Not more than four hours' normal travel time from Installer's place of business to Project site.
2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.

B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.

C. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL), and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

D. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.

E. 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.

F. Comply with ASME B15.1.

G. Comply with NFPA 37.

H. Comply with NFPA 70.

I. Comply with NFPA 99.

J. Comply with NFPA 110 requirements for Level 1 emergency power supply system.

K. Comply with UL 2200.

L. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

M. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.10 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Construction Manager no fewer than two days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Construction Manager's written permission.

B. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: 5 to 50 deg C.
2. Relative Humidity: 0 to 95 percent.
3. Altitude: Sea level to 1200 feet.

1.11 COORDINATION

A. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

B. Coordinate size and location of roof curbs, equipment supports, and roof penetrations for remote radiators. These items are specified in Section 07 72 00 "Roof Accessories."

1.12 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 5 years from date of Substantial Completion.

1.13 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Generac Power Systems, Inc. (Basis of Design)

2. Caterpillar; Engine Div.

3. Kohler Co.; Generator Division.

2.2 ENGINE-GENERATOR SET

A. Factory-assembled and -tested, engine-generator set.

B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

C. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated, with capacity as required to operate as a unit as evidenced by records of prototype testing.

2. Output Connections: Three-phase, four wire.
3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

D. Generator-Set Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: Comply with NFPA 110, Type 10, system requirements.

E. Generator-Set Performance for Sensitive Loads:

1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.

    a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.

2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not

less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.

9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.

    a. Provide permanent magnet excitation for power source to voltage regulator.

10. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.3 ENGINE

A. Fuel: Fuel oil, Grade DF-2.

B. Rated Engine Speed: 1800 rpm.

C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm.

D. Lubrication System: The following items are mounted on engine or skid:

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances. Crankcase drain shall be extended from the crankcase, through the enclosure, and down the side of the enclosure to the oil drain receiver tank (receiver tank provided by others). Do not hard connect the drain line to the tank. Terminate above the tank inlet with a 1" air gap. Furnish all hardware up to the air gap. Coordinate with the fuel and lubrication equipment vendor on the gen set supplier's preferred location of the termination.

E. Engine Fuel System:

1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.

G. Governor: Adjustable isochronous, with speed sensing.

H. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.

4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.

    a. Rating: 50-psig maximum working pressure with coolant at 180 deg F, and noncollapsible under vacuum.
    b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

I. Cooling System: Closed loop, liquid cooled, with integral engine-driven coolant pump.

1. Configuration: Horizontal air discharge. See plans for air discharge arrangement. Provide unit to suit.
2. Radiator Core Tubes: Nonferrous-metal construction other than aluminum.
3. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
4. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
5. Fan: Driven by totally enclosed electric motor with sealed bearings.
6. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
7. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

J. Muffler/Silencer:

1. Minimum sound attenuation of 30 dB at 500 Hz.
2. Sound level measured at a distance of 10 feet from exhaust discharge after installation is complete shall be 80 dBA or less.

K. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

L. Starting System: 24-V electric, with negative ground.

1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: As required by NFPA 110 for system level specified.
4. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least three times without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.
7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.

8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:

    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
    c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
    d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
    e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
    f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.4 FUEL OIL STORAGE

A. Comply with NFPA 30.

B. Provide UL 142 belly tank below generator set installed in accordance with local Fire Code, factory-fabricated fuel tank assembly, with integral, fuel pumps and the following features:

1. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of tank.

    a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.

2. Tank Capacity: As specified on plans for an uninterrupted period of 72 hours' operation at 100 percent of rated power output of engine-generator system without being refilled. Tank shall be fed from outdoor fuel transfer system (see FP-1 by fuel system contractor).
3. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
4. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
5. Spare Bungs: Provide (2) spare 2” NPT bungs for fuel delivery system supply pipe connection and liquid level sensors. Pump Failures: Failure of either pump shall automatically trigger and alarm to the BCS system.
6. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level. Shut off of pump shall also close solenoid fuel valve to tank provided by FP-1 supplier. Piping Connections: Factory-installed fuel supply and return lines from each tank to engine; local fuel fill with removable cap, vent line, overflow line; and tank drain line with shutoff valve. Fuel pipe from the main outdoor fill point provided by the fill port supplier FP-1. Three actuated solenoid fire and petroleum rated valves will be provided for connection to day tanks by the gen set vendor. Vent lines shall exit building and be located above roof per Local Fire Code. Vent lines shall be provided by the gen set installer from the tanks to the vent stack risers through the roof. Connection to tanks by the gen set supplier.

Normal and emergency vent lines shall be provided to each tank and extended through roof to outdoors.

7. Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in tank. Sensor shall initiate an alarm signal to control panel but shall not shut down engine-generator set.

2.5 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel integrated with the paralleling controls per 26 23 13.

D. Indicating and Protective Devices and Controls:

1. AC voltmeter.
2. AC ammeter.
3. AC frequency meter.
4. DC voltmeter (alternator battery charging).
5. Engine-coolant temperature gage.
6. Engine lubricating-oil pressure gage.
7. Running-time meter.
8. Ammeter-voltmeter, phase-selector switch(es).
9. Generator-voltage adjusting rheostat.
10. Start-stop switch.
11. Overspeed shutdown device.
12. Coolant high-temperature shutdown device.
13. Coolant low-level shutdown device.
14. Oil low-pressure shutdown device.
15. Fuel tank derangement alarm.
16. Fuel tank high-level shutdown of fuel supply alarm.
17. Generator overload.

E. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

F. Connection to Data Link: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of indications to remote data terminals. Data system connections to terminals are covered in Section 26 09 13 "Electrical Power Monitoring and Control."

G. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.

1. Overcrank shutdown.
2. Coolant low-temperature alarm.
3. Control switch not in auto position.
4. Battery-charger malfunction alarm.
5. Battery low-voltage alarm.

H. Common Remote Audible Alarm: Signal the occurrence of any events listed below without differentiating between event types. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset.

1. Engine high-temperature shutdown.
2. Lube-oil, low-pressure shutdown.
3. Overspeed shutdown.
4. Remote emergency-stop shutdown.
5. Engine high-temperature prealarm.
6. Lube-oil, low-pressure prealarm.
7. Fuel tank, low-fuel level.
8. Low coolant level.

I. Remote Alarm Annunciator: Comply with NFPA 99. An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

J. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.6 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Circuit Breaker: Insulated-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
2. Trip Settings: Selected to coordinate with generator thermal damage curve.
3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

B. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector shall perform the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.

2. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

C. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

2.7 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

F. Enclosure: Dripproof.

G. Instrument Transformers: Mounted within generator enclosure.

H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.

1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.

I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

K. Subtransient Reactance: 12 percent, maximum.

2.8 LOAD BANK AND TEMPORARY GENERATOR LUG ENCLOSURE

A. Description: Permanent, outdoor, weatherproof enclosure with lugs for connection to temporary load bank or temporary generator. (When indicated on plans)

2.9 OUTDOOR GENERATOR-SET ENCLOSURE

A. Description: Vandal-resistant, weatherproof steel housing, wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components requiring

maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

B. Description: Prefabricated or pre-engineered C18 sound attenuated walk-in enclosure with the following features:

1. Construction: Galvanized-steel, metal-clad, integral structural-steel-framed building erected on concrete foundation.
2. Structural Design and Anchorage: Comply with ASCE 7 for wind loads.
3. Space Heater: Thermostatically controlled and sized to prevent condensation.
4. Louvers: Equipped with bird screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust, birds, and rodents.
5. Hinged Doors: With padlocking provisions.
6. Ventilation: Louvers equipped with bird screen and filter arranged to permit air circulation while excluding exterior dust, birds, and rodents.
7. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine-generator-set components.
8. Muffler Location: External to enclosure. (see plans)
9. Maximum sound pressure levels at full load: 85dBA at 1 meter, 76dBA at 7 meters.

C. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.

1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.

D. Interior Lights with Switch: Factory-wired, vaporproof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.

1. AC lighting system and connection point for operation when remote source is available.
2. DC lighting system for operation when remote source and generator are both unavailable.

E. Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.

2.10 MOTORS

A. General requirements for motors are specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

2.11 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of

sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: Standard neoprene Natural rubber Bridge-bearing neoprene, complying with AASHTO M 251.
2. Durometer Rating: 70 .
3. Number of Layers: Four .

B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.12 FINISHES

A. Indoor and Outdoor Enclosures and Components: Color shall be as selected by the architect. Selected finish over corrosion-resistant pretreatment and compatible primer.

2.13 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
2. Full load run.
3. Maximum power.
4. Voltage regulation.
5. Transient and steady-state governing.
6. Single-step load pickup.
7. Safety shutdown.
8. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
9. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.

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

3.2 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

C. Install packaged engine generator with restrained spring isolators having a minimum deflection of 1 inch on 4-inch- high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."

D. Install remote radiator with restrained spring isolators having a minimum deflection of 1 inch on concrete base on grade.

E. Install Schedule 40, black steel piping with welded joints for cooling water piping between engine-generator set and heat exchanger. Piping materials and installation requirements are specified in Section 23 21 13 "Hydronic Piping."

F. See mechanical plans and generator exhaust schedule (Sheet M053) for generator exhaust requirements.

G. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.

C. Connect cooling-system water piping to engine-generator set and heat exchanger with flexible connectors.

D. Connect engine exhaust pipe to engine with flexible connector.

E. Connect fuel piping to engines with a gate valve and union and flexible connector.

1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are specified in Section 23 11 13 "Facility Fuel-Oil Piping."
2. Natural-gas piping, valves, and specialties for gas distribution are specified in Section 23 11 23 "Facility Natural-Gas Piping."
3. LP-gas piping, valves, and specialties for gas piping are specified in Section 23 11 26 "Facility Liquefied-Petroleum Gas Piping."

F. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.4 IDENTIFICATION

A. Identify system components according to Section 23 05 53 "Identification for HVAC Piping and Equipment" and Section 26 05 53 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections per the latest NETA Acceptance Testing Specifications and prepare test reports.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

C. Tests and Inspections:

1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
    a. With the prime mover in a "cold start" condition, simulate all building loads with a load bank and perform NFPA 110 7.13.4.1. test for 2 hours.
    b. Allow prime mover to cool for 5 min per NFPA 110 7.13.5.
    c. Perform 2 hour full load 100% of the nameplate kW test per NFPA 110 7.13.16.
3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

    a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
    b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
    c. Verify acceptance of charge for each element of the battery after discharge.
    d. Verify that measurements are within manufacturer's specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.

5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg. Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
7. Exhaust Emissions Test: Comply with applicable government test criteria.
8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
9. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
10. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.

D. Perform the commissioning Functional Performance Tests after completion of the NETA tests and manufacturer service startup tests. Functional Performance Test procedures to be developed by and witnessed by the CxA (see Section 26 08 00). The functional performance tests shall include all applicable tests listed in Paragraph C above, organized into the following groups of tests.
1. Fuel system tests and alarm verification tests including remote annunciation
2. Generator safeties and alarm verification tests including remote annunciation
3. Generator emergency shutdown button tests
4. Generator engineer crank test and battery charge rate test
5. Generator load bank performance tests (including NFPA 110 requirements)

E. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.

F. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

G. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

H. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

I. Remove and replace malfunctioning units and retest as specified above.

J. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

K. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

L. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators. Refer to Section 01 79 00 "Demonstration and Training."

END OF SECTION

SECTION 26 33 53
STATIC UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. SCOPE: PROVIDE LABOR, MATERIAL, EQUIPMENT, RELATED SERVICES FOR INSTALLATION OF THE STATIC UNINTERRUPTIBLE POWER SUPPLY (UPS) AS SHOWN ON THE DRAWINGS AND AS HEREIN SPECIFIED.

UPS #1A/1B, KW/KVA PER ONE-LINE DIAGRAM

B. SECTION INCLUDES: THE WORK SPECIFIED IN THIS SECTION INCLUDES, BUT SHALL NOT BE LIMITED TO, A CONTINUOUS DUTY, THREE-PHASE, SOLID STATE, ON-LINE DOUBLE CONVERSION STATIC UPS. ALL PROGRAMMING AND MISCELLANEOUS COMPONENTS FOR A FULLY OPERATIONAL SYSTEM AS DESCRIBED IN THIS SECTION SHALL BE AVAILABLE AS PART OF THE UPS.

1.2 SYSTEM DESCRIPTION

A. DESIGN REQUIREMENTS:
1. **THE UPS SHALL BE SIZED FOR KVA AND KW LOAD AS INDICATED ON THE ONE-LINE. BATTERY SHALL BE SIZED FOR 100% LOAD AT A POWER FACTOR OF 1.0 FOR 5 MINUTES.**
2. **THE UPS SYSTEM LAYOUT SHALL BE COORDINATED WITH PROPOSED ROOM DIMENSIONS.**

B. SYSTEM CHARACTERISTICS:

a. INPUT: THE SYSTEM INPUT SHALL BE CONFIGURED AS DUAL MAINS DERIVED FROM A THREE PHASE WYE SOURCE. STANDARD CABLE ENTRY SHALL BE THROUGH THE TOP. BOTTOM CABLE ENTRY SHALL ALSO BE FACILITATED.
b. AC INPUT NOMINAL VOLTAGE: SYSTEM VOLTAGE SHALL SUPPORT 3-PHASE + NEUTRAL + GROUND IN A DUAL MAINS CONFIGURATION
c. AC INPUT VOLTAGE WINDOW:
   1) ±15 PERCENT FOR FULL PERFORMANCE.
d. -SHORT CIRCUIT WITHSTAND RATING:
   1) UPS: 30,000 SYMMETRICAL AMPERES.
   2) MAINTENANCE BYPASS: 25,000 SYMMETRICAL AMPERES
e. INPUT CURRENT IN NORMAL OPERATION: WITH NO CHARGING, A MAXIMUM OF 105 PERCENT OF SYSTEM CAPACITY
f. INPUT CURRENT DISTORTION WITH NO ADDITIONAL FILTERS: LESS THAN 5 PERCENT.
g. SOFT-START: SHALL BE LINEAR FROM 0 PERCENT TO 100 PERCENT INPUT CURRENT AND SHALL NOT EXHIBIT INRUSH. FACTORY DEFAULT OF 15 SECONDS.
h. UPS OUTPUT:
   1) AC OUTPUT NOMINAL OUTPUT: SYSTEM VOLTAGE SHALL SUPPORT 3-PHASES + NEUTRAL + GROUND
i. GRAPHICAL USER INTERFACE BY SERVICE PERSONNEL WITH THE FOLLOWING OPTIONS:

j. AC OUTPUT VOLTAGE DISTORTION: LESS THAN 2 PERCENT AT 100 PERCENT LINEAR LOAD, LESS THAN 3 PERCENT FOR SMPS LOAD AS DEFINED BY IEC 62040-3.
k. AC OUTPUT VOLTAGE REGULATION: ±1 PERCENT FOR 100 PERCENT LINEAR OR NON-LINEAR LOAD.
l. VOLTAGE TRANSIENT RECOVERY: WITHIN LESS THAN 50 MILLISECONDS.
m. OUTPUT VOLTAGE HARMONIC DISTORTION: LESS THAN 2 PERCENT THD MAXIMUM AND 1 PERCENT SINGLE HARMONIC FOR A 100 PERCENT LINEAR LOAD.
n. OVERLOAD RATING:
    1) NORMAL OPERATION:
        a) 150 PERCENT FOR 30 SECONDS BEFORE TRANSFER TO BYPASS.
        b) 125 PERCENT FOR 10 MINUTES BEFORE TRANSFER TO BYPASS.
    2) BATTERY OPERATION: 125 PERCENT FOR 30 SECONDS (UP TO 10 MINUTES WITH FULLY CONFIGURED BATTERY SOLUTION)
    3) BYPASS OPERATION:
        a) 125 PERCENT CONTINUOUS.
        b) 1000 PERCENT FOR 100 MILLISECONDS.
o. SYSTEM AC-AC EFFICIENCY:
    1) NORMAL OPERATION GREATER THAN 96 PERCENT AT 40 PERCENT TO 100 PERCENT LOAD.
    2) BATTERY OPERATION GREATER THAN 95 PERCENT AT 40 PERCENT TO 100 PERCENT LOAD.
p. OUTPUT POWER FACTOR RATING: 0.5 LEADING TO 0.5 LAGGING WITHOUT ANY DERATING.

2. CHARGE CURRENT:
    a. 20% OF CHARGING CAPACITY WHEN THE LOAD IS LESS THAN 90%
    b. 10% OF CHARGING CAPACITY WITH 100% LOAD
3. REGULATORY COMPLIANCE: THE UPS SHALL COMPLY WITH THE FOLLOWING STANDARDS: UNDERWRITERS LABORATORIES, INC. (UL):

1.3 SUBMITTALS

A. SHOP DRAWINGS: SUBMIT SHOP DRAWINGS FOR EACH PRODUCT AND ACCESSORY REQUIRED. INCLUDE INFORMATION NOT FULLY DETAILED IN MANUFACTURER'S STANDARD PRODUCT DATA, INCLUDING, BUT NOT LIMITED TO, THE FOLLOWING:
1. INSTALLATION INFORMATION, INCLUDING, BUT NOT LIMITED TO, WEIGHTS AND DIMENSIONS.
2. INFORMATION ABOUT TERMINAL LOCATIONS FOR POWER AND CONTROL CONNECTIONS.
3. DRAWINGS FOR REQUESTED OPTIONAL ACCESSORIES.
4. WIRING DIAGRAMS
5. SINGLE-LINE DIAGRAM

B. OPERATION AND MAINTENANCE DATA: SUBMIT OPERATION AND MAINTENANCE DATA TO INCLUDE IN OPERATION AND MAINTENANCE MANUALS, INCLUDING, BUT NOT LIMITED TO, SAFE AND CORRECT OPERATION OF UPS FUNCTIONS.
1. SUBMIT AN INSTALLATION MANUAL, WHICH SHALL INCLUDE, BUT SHALL NOT BE LIMITED TO, INSTRUCTIONS FOR STORAGE, HANDLING, EXAMINATION, PREPARATION, INSTALLATION, AND START-UP OF UPS.
2. SUBMIT AN OPERATION AND MAINTENANCE MANUAL, WHICH SHALL INCLUDE, BUT SHALL NOT BE LIMITED TO, OPERATING INSTRUCTIONS.

1.4 DELIVERY, STORAGE, AND HANDLING

A. DELIVER MATERIALS TO THE PROJECT SITE IN SUPPLIER'S OR MANUFACTURER'S ORIGINAL WRAPPINGS AND CONTAINERS, LABELED WITH SUPPLIER'S OR MANUFACTURER'S NAME, MATERIAL OR PRODUCT BRAND NAME, AND LOT NUMBER, IF ANY. THE CUSTOMER SHALL STORE MATERIALS IN THEIR ORIGINAL, UNDAMAGED PACKAGES AND CONTAINERS, INSIDE A WELL-VENTILATED AREA PROTECTED FROM WEATHER, MOISTURE, SOILING, EXTREME TEMPERATURES, AND HUMIDITY.

1.5 WARRANTY

A. THE CONTRACTOR SHALL WARRANT THE WORK OF THIS SECTION TO BE IN ACCORDANCE WITH THE CONTRACT DOCUMENTS AND FREE FROM FAULTS AND DEFECTS IN MATERIALS AND WORKMANSHIP FOR A PERIOD OF 24 MONTHS FROM THE DATE OF INSTALLATION OR 30 MONTHS FROM DATE OF SHIPMENT FROM THE MANUFACTURER, WHICHEVER OCCURS FIRST..

1.6 MAINTENANCE

A. A COMPLETE OFFERING OF PREVENTATIVE AND FULL SERVICE MAINTENANCE CONTRACTS FOR THE UPS SYSTEM AND THE BATTERY SYSTEM SHALL BE AVAILABLE FROM THE MANUFACTURER. CONTRACT WORK SHALL BE PERFORMED BY FACTORY TRAINED SERVICE PERSONNEL.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. BASIS OF DESIGN: PRODUCT SPECIFIED IS S"SCHNEIDER PX SERIES" AS MANUFACTURED BY APC BY SCHNEIDER ELECTRIC. ITEMS SPECIFIED ARE TO ESTABLISH A STANDARD OF QUALITY FOR DESIGN, FUNCTION, MATERIALS, AND APPEARANCE. EQUIVALENT PRODUCTS BY OTHER MANUFACTURERS ARE ACCEPTABLE. THE ARCHITECT/ENGINEER WILL BE THE SOLE JUDGE OF THE BASIS OF WHAT IS EQUIVALENT.

2.2 MODES OF OPERATION

A. NORMAL: THE PFC (POWER FACTOR CORRECTED INPUT RECTIFIER/BOOST CONVERTER) INPUT STAGE AND OUTPUT INVERTER SHALL OPERATE IN AN ON-LINE MANNER TO CONTINUOUSLY REGULATE POWER TO THE CRITICAL LOAD. THE INPUT AND OUTPUT CONVERTERS SHALL BE CAPABLE OF FULL BATTERY RECHARGE WHILE SIMULTANEOUSLY PROVIDING REGULATED POWER TO THE LOAD FOR ALL LINE AND LOAD CONDITIONS WITHIN THE RANGE OF THE UPS SPECIFICATIONS.

B. BATTERY: UPON FAILURE OF THE AC INPUT SOURCE, THE CRITICAL LOAD SHALL CONTINUE BEING SUPPLIED BY THE OUTPUT INVERTER, WHICH SHALL DERIVE ITS POWER FROM THE BATTERY SYSTEM. THERE SHALL BE NO INTERRUPTION IN POWER TO THE CRITICAL LOAD DURING BOTH TRANSFERS TO BATTERY OPERATION AND RETRANSFERS FROM BATTERY TO NORMAL OPERATION. UPON RESTORATION OF UTILITY POWER TO THE UPS INPUT, THE UPS SHALL RECHARGE THE BATTERY.

C. STATIC BYPASS: THE STATIC BYPASS SHALL BE USED TO PROVIDE CONTROLLED TRANSFER OF CRITICAL LOAD FROM THE INVERTER OUTPUT TO THE BYPASS SOURCE. THIS TRANSFER, ALONG WITH ITS RETRANSFER, SHALL TAKE PLACE WITH NO POWER INTERRUPTION TO THE CRITICAL LOAD. IN THE EVENT OF A UPS OUTPUT FAULT OR SIGNIFICANT OUTPUT OVERLOAD EMERGENCY, THIS TRANSFER SHALL BE AN AUTOMATIC FUNCTION. MANUAL TRANSFER TO STATIC BYPASS (CALLED "REQUESTED BYPASS") SHALL BE AVAILABLE IN ORDER TO FACILITATE A CONTROLLED TRANSFER TO

MAINTENANCE BYPASS. [THESE SYSTEMS ARE NOT TO BE CONNECTED TOGETHER FOR PARALLELING OPERATION.]

D. MAINTENANCE BYPASS: THE SYSTEM SHALL BE EQUIPPED WITH AN EXTERNAL MBWD TO ELECTRICALLY ISOLATE THE UPS DURING ROUTINE MAINTENANCE AND SERVICE OF THE UPS. THE MBWD SHALL ALLOW FOR THE COMPLETELY ELECTRICAL ISOLATION OF THE UPS.

2.3 DISPLAY AND CONTROLS

A. GRAPHICAL USER INTERFACE: A MICROPROCESSOR-CONTROLLED USER INTERFACE/DISPLAY UNIT SHALL BE LOCATED ON THE FRONT OF THE SYSTEM.

B. COMMUNICATION INTERFACE BOARD: A COMMUNICATION INTERFACE BOARD SHALL PROVIDE THE FOLLOWING COMMUNICATION PORTS WHICH SHALL BE ABLE TO BE USED SIMULTANEOUSLY: ETHERNET, MODBUS RS485, BACNET

2.4 BATTERY

A. THE UPS BATTERY SHALL SUPPORT A BATTERY PLANT OF MODULAR CONSTRUCTION MADE UP OF OWNER-REPLACEABLE, HOT-SWAPPABLE, FUSED, BATTERY MODULES. EACH BATTERY MODULE SHALL BE MONITORED FOR VOLTAGE AND TEMPERATURE FOR USE BY THE UPS BATTERY DIAGNOSTIC.

B. THE BATTERY JARS HOUSED WITHIN EACH REMOVABLE BATTERY MODULE SHALL BE OF THE VALVE REGULATED LEAD ACID (VRLA) TYPE.

C. THE UPS SHALL INCORPORATE A BATTERY MANAGEMENT SYSTEM TO CONTINUOUSLY MONITOR THE STATUS OF EACH REMOVABLE BATTERY MODULE. THIS SYSTEM SHALL NOTIFY THE OWNER IN THE EVENT A FAILED OR WEAK BATTERY MODULE IS FOUND.

D. THE BATTERIES SHALL BE LONG LIFE BATTERIES (5 TO 8 YEARS) AND THE BATTERY CASING SHALL BE FLAME RETARDANT TYPE.

E. THE UPS SHALL INCORPORATE A BATTERY CAPACITY TEST THAT WILL BE CAPABLE OF DETERMINING AVAILABLE RUNTIMES.

2.9 MANUFACTURER FIELD SERVICE:

1. THE UPS MANUFACTURER SHALL HAVE A WORLDWIDE SERVICE ORGANIZATION AVAILABLE, CONSISTING OF FACTORY-TRAINED FIELD SERVICE PERSONNEL TO PERFORM START-UP, PREVENTATIVE MAINTENANCE, AND SERVICE OF THE UPS SYSTEM AND POWER EQUIPMENT. THE SERVICE ORGANIZATION SHALL OFFER 24 HOURS A DAY, 7 DAYS A WEEK, 365 DAYS A YEAR SERVICE SUPPORT. REPLACEMENT PARTS: PARTS SHALL BE AVAILABLE THROUGH THE WORLDWIDE SERVICE ORGANIZATION 24 HOURS A DAY, 7 DAYS A WEEK, 365 DAYS A YEAR. THE WORLDWIDE SERVICE ORGANIZATION SHALL BE CAPABLE OF SHIPPING PARTS WITHIN FOUR WORKING HOURS OR ON THE NEXT AVAILABLE FLIGHT, SO THAT THE PARTS MAY BE DELIVERED TO THE OWNER WITHIN 24 HOURS.

PART 3 - EXECUTION

3.1 EXAMINATION

A. VERIFICATION OF CONDITIONS: TO ENSURE FULL WARRANTY COVERAGE, A SCHNEIDER ELECTRIC CERTIFIED TECHNICIAN MUST PERFORM THE START-UP SERVICE. EXAMINE

AREAS AND CONDITIONS UNDER WHICH THE WORK IS TO BE INSTALLED, AND NOTIFY THE CONTRACTOR IN WRITING, WITH A COPY TO THE OWNER AND THE ARCHITECT/ENGINEER, OF ANY CONDITIONS DETRIMENTAL TO THE PROPER AND TIMELY COMPLETION OF THE WORK. DO NOT PROCEED WITH THE WORK UNTIL UNSATISFACTORY CONDITIONS HAVE BEEN CORRECTED.

1. BEGINNING OF THE WORK SHALL INDICATE ACCEPTANCE OF THE AREAS AND CONDITIONS AS SATISFACTORY BY THE INSTALLER.

3.2 INSTALLATION

A. FACTORY-ASSISTED START-UP: FACTORY-TRAINED SERVICE PERSONNEL SHALL PERFORM THE FOLLOWING INSPECTIONS, TEST PROCEDURES, AND ON-SITE TRAINING:
   1. ON-SITE OPERATIONAL TRAINING: DURING THE FACTORY-ASSISTED START-UP, OPERATIONAL TRAINING FOR SITE PERSONNEL SHALL INCLUDE, BUT SHALL NOT BE LIMITED TO, KEY PAD OPERATION, LED INDICATORS, START-UP AND SHUTDOWN PROCEDURES, MAINTENANCE BYPASS AND AC DISCONNECT OPERATION, AND ALARM INFORMATION.

3.3 FIELD QUALITY CONTROL

A. MANUFACTURER'S FIELD SERVICE: ENGAGE A FACTORY-AUTHORIZED SERVICE REPRESENTATIVE TO INSPECT, TEST, AND ADJUST COMPONENTS, ASSEMBLIES, AND EQUIPMENT INSTALLATIONS, INCLUDING CONNECTIONS

B. TESTS AND INSPECTIONS
   1. TEST MANUAL AND AUTOMATIC OPERATIONAL FEATURES AND SYSTEM PROTECTIVE AND ALARM FUNCTIONS.
   2. TEST COMMUNICATION OF STATUS AND ALARMS TO REMOTE MONITORING EQUIPMENT
   3. LOAD THE SYSTEM USING A VARIABLE-LOAD BANK TO SIMULATE LOAD STEPS AND UNIT PERFORMANCE
      a. SIMULATE MALFUNCTIONS TO VERIFY PROTECTIVE DEVICE OPERATION
      b. TEST DURATION OF SUPPLY ON EMERGENCY.
      c. TEST OUTPUT VOLTAGE UNDER SPECIFIED TRANSIENT-LOAD CONDITIONS.
      d. TEST REMOTE STATUS AND ALARM PANEL FUNCTIONS.
      e. TEST BATTERY-MONITORING SYSTEM FUNCTIONS.
      f. TEST AND ADJUST CONTROLS AND SAFETIES INCLUDING EXHAUST FAN INTERLOCKS. REPLACE DAMAGED OR MALFUNCTIONING CONTROLS AND EQUIPMENT.

3.4 DEMONSTRATION

A. GENERAL: PROVIDE THE SERVICES OF A FACTORY-AUTHORIZED SERVICE REPRESENTATIVE OF THE MANUFACTURER TO PROVIDE START-UP SERVICE AND TO DEMONSTRATE AND TRAIN THE OWNER’S PERSONNEL INCLUDING KEY PAD OPERATION, LED INDICATORS, START-UP AND SHUTDOWN PROCEDURES, MAINTENANCE BYPASS AND AC DISCONNECT OPERATION, AND ALARM INFORMATION. TRAIN THE OWNER’S MAINTENANCE PERSONNEL ON PROCEDURES AND SCHEDULES RELATED TO START-UP AND SHUTDOWN, TROUBLESHOOTING, SERVICING, AND PREVENTIVE MAINTENANCE.

SECTION 26 36 00

TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes transfer switches rated 600 V and less, including the following:

1. Automatic transfer switches.
2. Bypass/isolation switches.
3. Remote annunciation systems.
4. Remote annunciation and control systems.

B. Provide switches with ratings, no. of poles, AIC, as indicated on plans.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

1. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer.

B. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

1. Features and operating sequences, both automatic and manual.
2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain automatic transfer switches through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NEMA ICS 1.

F. Comply with NFPA 70.

G. Comply with NFPA 99.

H. Comply with NFPA 110.

I. Comply with UL 1008 unless requirements of these Specifications are stricter.

1.7 FIELD CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service:

1. Notify Construction Manager no fewer than two days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Construction Manager's written permission.

1.8 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 03 30 00 "Cast-in-Place Concrete."

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Contactor Transfer Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Generac (Basis of Design)

b. ASCO

c. Caterpillar; Engine Div.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.

C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.

G. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.

H. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

I. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Section 26 05 53 "Identification for Electrical Systems."

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.

J. Enclosures: General-purpose NEMA 250, Type 12, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.3 AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

D. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.

E. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of transfer to emergency source AND retransfer to normal source. Interval is adjustable from 1 to 30 seconds.

F. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

G. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.

H. Automatic Transfer-Switch Features:

1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30

minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
b. Push-button programming control with digital display of settings.
c. Integral battery operation of time switch when normal control power is not available.

2.4 REMOTE ANNUNCIATOR SYSTEM

A. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches. Annunciation shall include the following:

1. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
2. Switch position.
3. Switch in test mode.
4. Failure of communication link.

B. Annunciator Panel: LED-lamp type with audible signal and silencing switch.

1. Indicating Lights: Grouped for each transfer switch monitored.
2. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
3. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.
4. Lamp Test: Push-to-test or lamp-test switch on front panel.

2.5 CONTROL SYSTEM

A. Functional Description: Include the following functions for indicated transfer switches:

1. Indication of sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
2. Indication of switch position.
3. Indication of switch in test mode.
4. Indication of failure of digital communication link.
5. Key-switch or user-code access to control functions of panel.
6. Control of switch-test initiation.
7. Control of switch operation in either direction.
8. Control of time-delay bypass for transfer to normal source.

B. Malfunction of annunciator, annunciation and control panel, or communication link shall not affect functions of automatic transfer switch. In the event of failure of communication link, automatic transfer switch automatically reverts to stand-alone, self-contained operation. Automatic transfer-switch sensing, controlling, or operating function shall not depend on remote panel for proper operation.

C. Control Panel: Solid-state components. Include the following features:

1. Each transfer switch shall have dedicated controls and operator interface panel connected to generator paralleling controller for monitoring. See Section 26 23 13 Engine Generator Paralleling.

2. Digital Communication Capability: Matched to that of paralleling controller(s).
3. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.

2.6 SOURCE QUALITY CONTROL

A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."

B. Floor-Mounting Switch: Anchor to floor by bolting.

1. Concrete Bases: 4 inches high, reinforced, with chamfered edges. Extend base no more than 4 inches in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Section 26 05 29 "Hangers and Supports for Electrical Systems."

C. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.

D. Identify components according to Section 26 05 53 "Identification for Electrical Systems."

E. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections per the latest NETA Acceptance Testing Specifications.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
2. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

    a. Check for electrical continuity of circuits and for short circuits.
    b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
    c. Verify that manual transfer warnings are properly placed.
    d. Perform manual transfer operation.

3. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.

    a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
    b. Verify time-delay settings.
    c. Verify pickup and dropout voltages by data readout or inspection of control settings.
    d. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
    e. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
    f. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
    g. Perform the commissioning Functional Performance Tests after completion of the NETA tests and manufacturer field service startup tests. Functional Performance Test procedures to be developed by and witnessed by the CxA (see Section 26 08 00). The functional performance tests shall include all applicable tests listed above, organized into the following groups of tests.
        1) Bypass Switch & Transfer Switch Engagement/Disengagement Tests with ATS in Normal Position
        2) Transfer Switch Tests on Loss of Normal Source
        3) Bypass Switch & Transfer Switch Engagement/Disengagement Tests with ATS in Emergency Position
        4) Transfer Switch tests on Return of Normal Source

4. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

    a. Verify grounding connections and locations and ratings of sensors.

D. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
1. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.

a. Simulate loss of phase-to-ground voltage for each phase of normal source.
b. Verify time-delay settings.
c. Verify pickup and dropout voltages by data readout or inspection of control settings.
d. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
e. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.

2. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

3. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
   a. Verify grounding connections and locations and ratings of sensors.

E. Coordinate tests with tests of generator and run them concurrently.

F. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

G. Remove and replace malfunctioning units and retest as specified above.

H. Prepare test and inspection reports.

I. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Refer to Section 01 79 00 "Demonstration and Training."

B. Coordinate this training with that for generator equipment.

END OF SECTION

SECTION 26 41 13

LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes lightning protection for structures.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For air terminals and mounting accessories.

1. Layout of the lightning protection system, along with details of the components to be used in the installation.
2. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer and manufacturer. Include data on listing or certification by UL.

B. Certification, signed by Contractor, that roof adhesive is approved by manufacturer of roofing material.

C. Field quality-control reports.

D. Comply with recommendations in NFPA 780, Annex D, "Inspection and Maintenance of Lightning Protection Systems," for maintenance of the lightning protection system.

E. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features, including the following:

1. Ground rods.
2. Ground loop conductor.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Certified by UL or LPI as a Master Installer/Designer, trained and approved for installation of units required for this Project.

B. System Certificate:

1. UL Master Label.
2. LPI System Certificate.
3. UL Master Label Recertification.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 780, "Definitions" Article.

1.6 COORDINATION

A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

B. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.

C. Flashings of through-roof assemblies shall comply with roofing manufacturers' specifications.

PART 2 - PRODUCTS

2.1 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. Comply with UL 96 and NFPA 780.

B. Roof-Mounted Air Terminals: NFPA 780, Class II, aluminum unless otherwise indicated.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. East Coast Lightning Equipment Inc.

b. ERICO International Corporation.

c. Harger.

d. Heary Bros. Lightning Protection Co. Inc.

e. Independent Protection Co.

f. Preferred Lightning Protection.

g. Robbins Lightning, Inc.

h. Thompson Lightning Protection, Inc.

i. VFC

3. Air Terminals More than 24 Inches Long: With brace attached to the terminal at not less than half the height of the terminal.
4. Single-Membrane, Roof-Mounted Air Terminals: Designed specifically for single-membrane roof system materials. Comply with requirements in roofing Sections.

C. Main and Bonding Conductors: Copper.

D. Ground Loop Conductor: The same size and type as the main conductor except tinned.

E. Ground Rods: Copper-clad steel; 5/8 inch in diameter by 96 inches long.

F. Heavy-Duty, Stack-Mounted, Lightning Protection Components: Stainless steel or Solid copper.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lightning protection components and systems according to UL 96A and NFPA 780.

B. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends.

C. Conceal the following conductors:

1. System conductors.
2. Down conductors.
3. Interior conductors.
4. Conductors within normal view of exterior locations at grade within 200 feet of building.

D. Cable Connections: Use crimped or bolted connections for all conductor splices and connections between conductors and other components. Use exothermic-welded connections in underground portions of the system.

E. Cable Connections: Use exothermic-welded connections for all conductor splices and connections between conductors and other components.

1. Exception: In single-ply membrane roofing, exothermic-welded connections may be used only below the roof level.

F. Air Terminals on Single-Ply Membrane Roofing: Comply with roofing membrane and adhesive manufacturer's written instructions.

G. Bond extremities of vertical metal bodies exceeding 60 feet in length to lightning protection components.

H. Ground Loop: Install ground-level, potential equalization conductor and extend around the perimeter of structure.

1. Bury ground ring not less than 24 inches from building foundation.

2. Bond ground terminals to the ground loop.
3. Bond grounded building systems to the ground loop conductor within 12 feet of grade level.

I. Bond lightning protection components with intermediate-level interconnection loop conductors to grounded metal bodies of building at 60-foot intervals.

3.2 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 05 44 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.3 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions cause deterioration or corrosion of conductors.

3.4 FIELD QUALITY CONTROL

A. Notify Architect at least 48 hours in advance of inspection before concealing lightning protection components.

B. UL Inspection: Meet requirements to obtain a UL Master Label for system.

C. LPI System Inspection: Meet requirements to obtain an LPI System Certificate.

END OF SECTION

SECTION 26 51 00

INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Interior lighting fixtures, lamps, ballasts, and controls.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.

1.3 DEFINITIONS

A. BF: Ballast factor.

B. CCT: Correlated color temperature.

C. CRI: Color-rendering index.

D. HID: High-intensity discharge.

E. LER: Luminaire efficacy rating.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting fixture, including ballast housing if provided.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

1. Physical description of lighting fixture including dimensions.
2. Emergency lighting units including battery and charger.
3. Ballast, including BF.
4. Energy-efficiency data.
5. Air and Thermal Performance Data: For air-handling lighting fixtures. Furnish data required in "Action Submittals" Article in Section 23 37 13 "Diffusers, Registers, and Grilles."

6. Sound Performance Data: For air-handling lighting fixtures. Indicate sound power level and sound transmission class in test reports certified according to standards specified in Section 23 37 13 "Diffusers, Registers, and Grilles."
7. Life, output (lumens, CCT, and CRI), and energy-efficiency data for lamps.
8. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing & Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.

    a. Testing Agency Certified Data: For indicated fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining fixtures shall be certified by manufacturer.
    b. Manufacturer Certified Data: Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom lighting fixtures. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

C. Samples: For each lighting fixture indicated in the Interior Lighting Fixture Schedule. Each Sample shall include the following:

1. Lamps and ballasts, installed.
2. Cords and plugs.
3. Pendant support system.

D. Installation instructions.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Lighting fixtures.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extends to within 12 inches of the plane of the luminaires.
4. Ceiling-mounted projectors.
5. Structural members to which suspension systems for lighting fixtures will be attached.
6. Other items in finished ceiling including the following:

    a. Air outlets and inlets.
    b. Speakers.
    c. Sprinklers.
    d. Smoke and fire detectors.
    e. Occupancy sensors.
    f. Access panels.

7. Perimeter moldings.

B. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.

C. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, from manufacturer.

D. Field quality-control reports.

E. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
2. Plastic Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Ballasts: One for every 100 of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910, complying with the IESNA Lighting Measurements Testing & Calculation Guides.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with NFPA 70.

E. FM Global Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

F. Mockups: Provide interior lighting fixtures for room or module mockups, complete with power and control connections.

1. Obtain Architect's approval of fixtures for mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
3. Approved fixtures in mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.10 WARRANTY

A. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Emergency Lighting Unit Batteries: 10 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.
2. Warranty Period for Emergency Ballast and Self-Powered Exit Sign Batteries: Seven years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining six years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide product indicated on Drawings.

2.2 GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

B. Metal Parts: Free of burrs and sharp corners and edges.

C. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp and ballast characteristics:

a. "USE ONLY" and include specific lamp type.
b. ANSI ballast type (M98, M57, etc.) for HID luminaires.
c. CCT and CRI for all luminaires.

F. Electromagnetic-Interference Filters: Factory installed to suppress conducted electromagnetic interference as required by MIL-STD-461E. Fabricate lighting fixtures with one filter on each ballast indicated to require a filter.

G. Air-Handling Fixtures: For use with plenum ceiling for air return and heat extraction and for attaching an air-diffuser-boot assembly specified in Section 23 37 13 "Diffusers, Registers, and Grilles."

1. Air-Supply Units: Slots in one or both side trims join with air-diffuser-boot assemblies.
2. Heat-Removal Units: Air path leads through lamp cavity.
3. Combination Heat-Removal and Air-Supply Unit: Heat is removed through lamp cavity at both ends of the fixture door with air supply same as for air-supply units.
4. Dampers: Operable from outside fixture for control of return-air volume.
5. Static Fixture: Air-supply slots are blanked off, and fixture appearance matches active units.

2.3 LIGHTING CONTROLS

A. Lighting controls shall be as scheduled on plans and control details or equivalent product offering to achieve the intended sequence of operation and control functions.

B. Lighting control supplier shall submit device cut sheets, typical wiring diagrams for approval by Engineer.

C. Acceptable manufacturers include,
1. Acuity / Sensorswitch (basis of design)
2. Cooper / Greengate
3. Wattstopper
4. Approved Equal

2.4 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:
1. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.
2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.

a. Battery: Sealed, maintenance-free, nickel-cadmium type.
b. Charger: Fully automatic, solid-state type with sealed transfer relay.

c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
f. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
g. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

C. Self-Luminous Signs: Powered by tritium gas, with universal bracket for flush-ceiling, wall, or end mounting. Signs shall be guaranteed by manufacturer to maintain the minimum brightness requirements in UL 924 for 20 years.

D. Self-Luminous Signs: Using strontium oxide aluminate compound to store ambient light and release the stored energy when the light is removed. Provide with universal bracket for flush-ceiling, wall, or end mounting.

2.5 EMERGENCY LIGHTING UNITS

A. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.

1. Battery: Sealed, maintenance-free, lead-acid type.
2. Charger: Fully automatic, solid-state type with sealed transfer relay.
3. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
6. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.
7. Integral Time-Delay Relay: Holds unit on for fixed interval of 15 minutes when power is restored after an outage.
8. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.6 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Section 26 05 29 "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.

F. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lighting fixtures:

1. Set level, plumb, and square with ceilings and walls unless otherwise indicated.
2. Install lamps in each luminaire.

B. Temporary Lighting: If it is necessary, and approved by Architect, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall.

C. Remote Mounting of Ballasts: Distance between the ballast and fixture shall not exceed that recommended by ballast manufacturer. Verify, with ballast manufacturers, maximum distance between ballast and luminaire.

D. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.

1. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each fixture. Locate not more than 6 inches from lighting fixture corners.
2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.

E. Suspended Lighting Fixture Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
4. Do not use grid as support for pendant luminaires. Connect support wires or rods to building structure.

F. Air-Handling Lighting Fixtures: Install with dampers closed and ready for adjustment.

G. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.2 IDENTIFICATION

A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

B. Verify that self-luminous exit signs are installed according to their listing and the requirements in NFPA 101.

C. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.4 TRAINING

A. Provide manufacturers representative for up to (1) site visit in addition to those required for start up to train facility staff in operation and capabilities of lighting control system, control panel, and wiring devices.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.

1. Adjust aimable luminaires in the presence of Architect and Owner.

END OF SECTION

SECTION 26 56 00

EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Exterior luminaires with lamps and ballasts.
2. Luminaire-mounted photoelectric relays.
3. Poles and accessories.
4. Luminaire lowering devices.

B. Related Sections:

1. Section 26 51 00 "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color-rendering index.

C. HID: High-intensity discharge.

D. LER: Luminaire efficacy rating.

E. Luminaire: Complete lighting fixture, including ballast housing if provided.

F. Pole: Luminaire support structure, including tower used for large area illumination.

G. Standard: Same definition as "Pole" above.

1.4 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

A. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4-M.

B. Live Load: Single load of 500 lbf, distributed as stated in AASHTO LTS-4-M.

C. Ice Load: Load of 3 lbf/sq. ft., applied as stated in AASHTO LTS-4-M Ice Load Map.

D. Wind Load: Pressure of wind on pole and luminaire and banners and banner arms, calculated and applied as stated in AASHTO LTS-4-M.

1. Basic wind speed for calculating wind load for poles exceeding 49.2 feet in height is 100 mph .

   a. Wind Importance Factor: 1.0.
   b. Minimum Design Life: 50 years.
   c. Velocity Conversion Factors: 1.0.

2. Basic wind speed for calculating wind load for poles 50 feet high or less is 100 mph.

   a. Wind Importance Factor: 1.0.
   b. Minimum Design Life: 25 years.
   c. Velocity Conversion Factors: 1.0.

1.5 ACTION SUBMITTALS

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:

1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
2. Details of attaching luminaires and accessories.
3. Details of installation and construction.
4. Luminaire materials.
5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.

   a. Testing Agency Certified Data: For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
   b. Manufacturer Certified Data: Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

6. Photoelectric relays.
7. Ballasts, including energy-efficiency data.
8. Lamps, including life, output, CCT, CRI, lumens, and energy-efficiency data.
9. Materials, dimensions, and finishes of poles.
10. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
11. Anchor bolts for poles.
12. Manufactured pole foundations.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
3. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.
4. Wiring Diagrams: For power, signal, and control wiring.

C. Samples: For products designated for sample submission in the Exterior Lighting Device Schedule. Each Sample shall include lamps and ballasts.

1.6 INFORMATIONAL SUBMITTALS

A. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations by a professional engineer.

B. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.

C. Field quality-control reports.

D. Warranty: Sample of special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and poles to include in emergency, operation, and maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: One for every 100 of each type and rating installed. Furnish at least one of each type.
2. Glass and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Ballasts: One for every 100 of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.9 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with IEEE C2, "National Electrical Safety Code."

E. Comply with NFPA 70.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B 660.

B. Store poles on decay-resistant-treated skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch deep. Do not apply tools to section of pole to be installed below ground line.

D. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.

E. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.11 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.

1. Warranty Period for Luminaires: Five years from date of Substantial Completion.
2. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
3. Warranty Period for Color Retention: Five years from date of Substantial Completion.
4. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide product indicated on Drawings.

2.2 GENERAL REQUIREMENTS FOR LUMINAIRES

A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

1. LER Tests Incandescent Fixtures: Where LER is specified, test according to NEMA LE 5A.
2. LER Tests Fluorescent Fixtures: Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
3. LER Tests HID Fixtures: Where LER is specified, test according to NEMA LE 5B.

B. Lateral Light Distribution Patterns: Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

C. Metal Parts: Free of burrs and sharp corners and edges.

D. Sheet Metal Components: Corrosion-resistant aluminum unless otherwise indicated. Form and support to prevent warping and sagging.

E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.

G. Exposed Hardware Material: Stainless steel.

H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

I. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

J. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

K. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

L. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

M. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

    a. Color: As selected from manufacturer's standard catalog of colors.
    b. Color: Match Architect's sample of manufacturer's standard color.
    c. Color: As selected by Architect from manufacturer's full range.

N. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.

    a. Color: As selected by Architect.

O. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp and ballast characteristics:

    a. "USES ONLY" and include specific lamp type.
    b. Lamp diameter code (T-4, T-5, T-8, T-12), tube configuration (twin, quad, triple), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.
    c. Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.
    d. Start type (preheat, rapid start, instant start) for fluorescent and compact fluorescent luminaires.
    e. ANSI ballast type (M98, M57, etc.) for HID luminaires.
    f. CCT and CRI for all luminaires.

2.3 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

A. Comply with UL 773 or UL 773A.

B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.

1. Relay with locking-type receptacle shall comply with ANSI C136.10.
2. Adjustable window slide for adjusting on-off set points.

C. Comply with ANSI C82.4 and UL 1029 and capable of open-circuit operation without reduction of average lamp life. Include the following features unless otherwise indicated:

1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
2. Minimum Starting Temperature: Minus 22 deg F.
3. Normal Ambient Operating Temperature: 104 deg F.
4. Ballast Fuses: One in each ungrounded power supply conductor. Voltage and current ratings as recommended by ballast manufacturer.

D. Auxiliary, Instant-On, Quartz System: Factory-installed feature automatically switches quartz lamp on when fixture is initially energized and when momentary power outages occur. System

automatically turns quartz lamp off when HID lamp reaches approximately 60 percent of light output.

E. High-Pressure Sodium Ballasts: Electromagnetic type with solid-state igniter/starter and capable of open-circuit operation without reduction of average lamp life. Igniter/starter shall have an average life in pulsing mode of 10,000 hours at an igniter/starter-case temperature of 90 deg C.

1. Instant-Restrike Device: Integral with ballast, or solid-state potted module, factory installed within fixture and compatible with lamps, ballasts, and mogul sockets up to 150 W.

a. Restrike Range: 105- to 130-V ac.
b. Maximum Voltage: 250-V peak or 150-V ac rms.

2. Minimum Starting Temperature: Minus 40 deg F.

2.4 GENERAL REQUIREMENTS FOR POLES AND SUPPORT COMPONENTS

A. Structural Characteristics: Comply with AASHTO LTS-4-M.

1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article.
2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.

B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.

1. Materials: Shall not cause galvanic action at contact points.
2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
3. Anchor-Bolt Template: Plywood or steel.

D. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless-steel captive screws.

E. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Section 03 30 00 "Cast-in-Place Concrete."

F. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.

G. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4-M.

2.5 STEEL POLES

A. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig; one-piece construction up to 40 feet in height with access handhole in pole wall.

1. Shape: As scheduled on the plans.
2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

B. Steel Mast Arms: As scheduled on the plans, continuously welded to pole attachment plate. Material and finish same as pole.

C. Brackets for Luminaires: Detachable, cantilever, without underbrace.

1. Adapter fitting welded to pole, allowing the bracket to be bolted to the pole mounted adapter, then bolted together with stainless-steel bolts.
2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
3. Match pole material and finish.

D. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

E. Steps: Fixed steel, with nonslip treads, positioned for 15-inch vertical spacing, alternating on opposite sides of pole; first step at elevation 10 feet above finished grade.

F. Intermediate Handhole and Cable Support: Weathertight, 3-by-5-inch handhole located at midpoint of pole with cover for access to internal welded attachment lug for electric cable support grip.

G. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

H. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.

I. Platform for Lamp and Ballast Servicing: Factory fabricated of steel with finish matching that of pole.

J. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

K. Galvanized Finish: After fabrication, hot-dip galvanize complying with ASTM A 123/A 123M.

L. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or with SSPC-SP 8, "Pickling."
2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.

3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

   a. Color: As selected by Architect from manufacturer's full range.

2.6 ALUMINUM POLES

A. Poles: Seamless, extruded structural tube complying with ASTM B 429/B 429M, Alloy 6063-T6 with access handhole in pole wall.

B. Poles: ASTM B 209, 5052-H34 marine sheet alloy with access handhole in pole wall.

1. Shape: As indicated on the plans.
2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

D. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

E. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.

1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.
2. Finish: Same as luminaire.

F. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

G. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.

   a. Color: As selected by Architect from manufacturer's full range.

2.7 FIBERGLASS POLES

A. Poles: Designed specifically for supporting luminaires, with factory-formed cable entrance and handhole. Not less than 65 percent fiberglass, with resin and pigment making up the remainder.

1. Resin Color: As scheduled; provide uniform coloration throughout entire wall thickness.
2. Surface Finish: Pigmented polyurethane, with a minimum dry film thickness of 1.5 mils. Polyurethane may be omitted if the surface layer of pole is inherently UV inhibited.

2.8 DECORATIVE POLES

A. Pole Material:

1. Cast ductile iron.
2. Cast gray iron, according to ASTM A 48/A 48M, Class 30.
3. Cast aluminum.
4. Cast concrete.
5. Spun concrete.
6. Steel tube, covered with closed-cell polyurethane foam, with a polyethylene exterior.

B. Mounting Provisions:

1. Bolted to concrete foundation.
2. Embedded.

C. Fixture Brackets:

1. Cast ductile iron.
2. Cast gray iron.
3. Cast aluminum.

D. Pole Finish: As scheduled.

2.9 PRESTRESSED CONCRETE POLES

A. Poles: Manufactured [by centrifugal spin-casting process] [of cast concrete].

1. Shape: As scheduled.
2. Mounting Provisions: Steel butt flange for bolted mounting to foundation or breakaway support.
3. Finishing: Capped at top and plugged at bottom. Seat each steel reinforcing strand with epoxy adhesive.
4. Grounding: Continuous copper ground wire cast into pole. Terminate at top of pole and attach to 24-inch lightning rod.

B. Cure with wet steam and age for a minimum of 15 days before installation.

C. Fabricate poles with a hard, nonporous surface that is resistant to water, frost, and road and soil chemicals and that has a maximum water-absorption rate of 3 percent.

D. Cast aluminum nameplate into pole wall at approximately 5 feet above ground line, listing name of manufacturer, Project identifier, overall height, and approximate weight.

E. Pole Brackets: Comply with ANSI C136.13.

F. Finish Color: Provided by color material complying with ASTM C 979, uniformly impregnated throughout the pole concrete. Color material shall provide a uniform, stable, permanent color and be as follows:

1. Inert, and carbon free.
2. Unaffected by environmental conditions and contaminants including, but not limited to, UV solar radiation, salts, and alkalis.

G. Finish Texture: Etched exposed aggregate.

2.10 POLE ACCESSORIES

A. Duplex Receptacle: 120 V, 20 A in a weatherproof assembly complying with Section 26 27 26 "Wiring Devices" for ground-fault circuit-interrupter type.

1. Recessed, 12 inches above finished grade.
2. Nonmetallic polycarbonate plastic or reinforced fiberglass, weatherproof in use, cover, that when mounted results in NEMA 250, Type 3R enclosure.
3. With cord opening.
4. With lockable hasp and latch that complies with OSHA lockout and tag-out requirements.

B. Minimum 1800-W transformer, protected by replaceable fuses, mounted behind access cover.

C. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.

D. Transformer Type Base: Same material and color as pole. Coordinate dimensions to suit pole's base flange and accept ballast(s).

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

A. Install lamps in each luminaire.

B. Fasten luminaire to indicated structural supports.

1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

3.2 POLE INSTALLATION

A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on Drawings:

1. Fire Hydrants and Storm Drainage Piping: 60 inches.
2. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet.
3. Trees: 15 feet from tree trunk.

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Section 03 30 00 "Cast-in-Place Concrete."

D. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.

1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
3. Install base covers unless otherwise indicated.
4. Use a short piece of 1/2-inch- diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Embedded Poles with Tamped Earth Backfill: Set poles to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.

1. Dig holes large enough to permit use of tampers in the full depth of hole.
2. Backfill in 6-inch layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.

F. Embedded Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.

1. Make holes 6 inches in diameter larger than pole diameter.
2. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi at 28 days, and finish in a dome above finished grade.
3. Use a short piece of 1/2-inch- diameter pipe to make a drain hole through concrete dome. Arrange to drain condensation from interior of pole.
4. Cure concrete a minimum of 72 hours before performing work on pole.

G. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch- wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch below top of concrete slab.

H. Raise and set poles using web fabric slings (not chain or cable).

3.3 BOLLARD LUMINAIRE INSTALLATION

A. Align units for optimum directional alignment of light distribution.

B. Install on concrete base with top 4 inches above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 03 30 00 "Cast-in-Place Concrete."

3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

A. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 03 30 00 "Cast-in-Place Concrete."

3.5 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 26 05 33 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.6 GROUNDING

A. Ground metal poles and support structures according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole unless otherwise indicated.
2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

B. Ground nonmetallic poles and support structures according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole.
2. Install grounding conductor and conductor protector.
3. Ground metallic components of pole accessories and foundations.

3.7 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.

1. Verify operation of photoelectric controls.

C. Illumination Tests:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IESNA testing guide(s):

a. IESNA LM-5, "Photometric Measurements of Area and Sports Lighting Installations."
b. IESNA LM-50, "Photometric Measurements of Roadway Lighting Installations."
c. IESNA LM-52, "Photometric Measurements of Roadway Sign Installations."
d. IESNA LM-64, "Photometric Measurements of Parking Areas."
e. IESNA LM-72, "Directional Positioning of Photometric Data."

D. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain luminaire lowering devices.

END OF SECTION

SECTION 270526

GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Grounding conductors.
2. Grounding connectors.
3. Grounding busbars.
4. Grounding rods.
5. Grounding labeling.

1.3 DEFINITIONS

A. BCT: Bonding conductor for telecommunications.

B. EMT: Electrical metallic tubing.

C. TGB: Telecommunications grounding busbar.

D. TMGB: Telecommunications main grounding busbar.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For communications equipment room signal reference grid. Include plans, elevations, sections, details, and attachments to other work.

1.5 INFORMATIONAL SUBMITTALS

A. As-Built Data: Plans showing as-built locations of grounding and bonding infrastructure, including the following:

1. Ground rods.

2. Ground and roof rings.
3. BCT, TMGB, TGBs, and routing of their bonding conductors.

B. Qualification Data: For Installer, installation supervisor, and field inspector.

C. Qualification Data: For testing agency and testing agency's field supervisor.

D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Result of the ground-resistance test, measured at the point of BCT connection.
b. Result of the bonding-resistance test at each TGB and its nearest grounding electrode.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Installation Supervision: Installation shall be under the direct supervision of ITS Installer, who shall be present at all times when Work of this Section is performed at Project site.
2. Field Inspector: Currently registered by BICSI as a registered communications distribution designer, ITS Installer to perform the on-site inspection.

PART 2 - PRODUCTS

2.1 SYSTEM COMPONENTS

A. Comply with J-STD-607-A.

2.2 CONDUCTORS

A. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. Harger Lightning and Grounding.
2. Panduit Corp.
3. Tyco Electronics Corp.

B. Comply with UL 486A-486B.

C. Insulated Conductors: Stranded copper wire, green or green with yellow stripe insulation, insulated for 600 V, and complying with UL 83.

1. Ground wire for custom-length equipment ground jumpers shall be No. 6 AWG, 19-strand, UL-listed, Type THHN wire.
2. Cable Tray Equipment Grounding Wire: No. 6 AWG.

D. Cable Tray Grounding Jumper:

1. Not smaller than No. 6 AWG (26 kcmils (13.3 sq. mm)) and not longer than 12 inches (300 mm). If jumper is a wire, it shall have a crimped grounding lug with two holes and long barrel for two crimps. If jumper is a flexible braid, it shall have a one-hole ferrule. Attach with grounding screw or connector provided by cable tray manufacturer.
2. Not smaller than No. 10 AWG (26 kcmils (13.3 sq. mm)) and not longer than 12 inches (300 mm). If jumper is a wire, it shall have a crimped grounding lug with one hole and standard barrel for one crimp. If jumper is a flexible braid, it shall have a one- or two-hole ferrule. Attach with grounding screw or connector provided by cable tray manufacturer.

E. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmils (14.2 sq. mm), 14 strands of No. 17 AWG conductor, and 1/4 inch (6.3 mm) in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.3 CONNECTORS

A. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.

B. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

C. Basis-of-Design Product: Subject to compliance with requirements, provide [product indicated on Drawings] <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. Burndy; Part of Hubbell Electrical Systems.
2. Chatsworth Products, Inc.
3. Harger Lightning and Grounding.
4. Panduit Corp.
5. Tyco Electronics Corp.

D. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.

1. Electroplated tinned copper, C and H shaped.

E. Signal Reference Grid Connectors: Combination of compression wire connectors, access floor grounding clamps, bronze U-bolt grounding clamps, and copper split-bolt connectors, designed for the purpose.

F. Busbar Connectors: Cast silicon bronze, solderless, compression or exothermic-type, mechanical connector; with a long barrel and two holes spaced on 1-inch (25.4-mm) centers for a two-bolt connection to the busbar.

G. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.4 GROUNDING BUSBARS

A. Manufacturers: Subject to compliance with requirements, [provide available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Chatsworth Products, Inc.
2. Harger Lightning and Grounding.
3. Panduit Corp.

C. TMGB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, 1/4 by 4 inches (6.3 by 100 mm) in cross section, length as indicated on Drawings. The busbar shall be NRTL listed for use as TMGB and shall comply with J-STD-607-A.

1. Predrilling shall be with holes for use with lugs specified in this Section.
2. Mounting Hardware: Stand-off brackets that provide a 4-inch (100-mm) clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.

3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.

D. TGB: Predrilled rectangular bars of hard-drawn solid copper, 1/4 by 2 inches (6.3 by 50 mm) in cross section, length as indicated on Drawings. The busbar shall be for wall mounting, shall be NRTL listed as complying with UL 467, and shall comply with J-STD-607-A.

1. Predrilling shall be with holes for use with lugs specified in this Section.
2. Mounting Hardware: Stand-off brackets that provide at least a 2-inch (50-mm clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.)
3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.

E. Rack and Cabinet Grounding Busbars: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with J-STD-607-A. Predrilling shall be with holes for use with lugs specified in this Section.

1. Cabinet-Mounted Busbar: Terminal block, with stainless-steel or copper-plated hardware for attachment to the cabinet.
2. Rack-Mounted Horizontal Busbar: Designed for mounting in 19- or 23-inch (483- or 584-mm) equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.
3. Rack-Mounted Vertical Busbar: 72 or 36 inches (1827 or 914 mm long), with stainless-steel or copper-plated hardware for attachment to the rack.

2.5 GROUND RODS

A. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. Harger Lightning and Grounding.
2. Tyco Electronics Corp.

B. Ground Rods: Copper-clad steel, 5/8 by 96 inches (16 by 2400 mm) in diameter.

2.6 LABELING

A. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. Brother International Corporation.

2. HellermannTyton.
3. Panduit Corp.

B. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the ac grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of the electrical system.

B. Inspect the test results of the ac grounding system measured at the point of BCT connection.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with connection of the BCT only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.

B. Comply with NECA 1.

C. Comply with J-STD-607-A.

3.3 APPLICATION

A. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

1. The bonding conductors between the TGB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
2. The bonding conductors between the TMGB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.

B. Underground Grounding Conductors: Install bare copper conductor, No. 2 AWG minimum.

C. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

D. Conductor Support:

1. Secure grounding and bonding conductors at intervals of not less than 36 inches (900 mm.)

E. Grounding and Bonding Conductors:

1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.
2. Install without splices.
3. Support at not more than 36-inch (900-mm) intervals.
4. Install grounding and bonding conductors in 3/4-inch (21-mm) PVC conduit until conduit enters a telecommunications room. The grounding and bonding conductor pathway through a plenum shall be in EMT. Conductors shall not be installed in EMT unless otherwise indicated.

a. If a grounding and bonding conductor is installed in ferrous metallic conduit, bond the conductor to the conduit using a grounding bushing that complies with requirements in Section 270528 "Pathways for Communications Systems," and bond both ends of the conduit to a TGB.

3.4 GROUNDING ELECTRODE SYSTEM

A. The BCT between the TMBG and the ac service equipment ground shall not be smaller than No. 3/0 AWG.

3.5 GROUNDING BUSBARS

A. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 12 inches (300 mm) above finished floor unless otherwise indicated.

B. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

3.6 CONNECTIONS

A. Bond metallic equipment in a telecommunications equipment room to the grounding busbar in that room, using equipment grounding conductors not smaller than No. 6 AWG.

B. Stacking of conductors under a single bolt is not permitted when connecting to busbars.

C. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:

1. Use crimping tool and the die specific to the connector.
2. Pretwist the conductor.
3. Apply an antioxidant compound to all bolted and compression connections.

D. Primary Protector: Bond to the TMGB with insulated bonding conductor.

E. Interconnections: Interconnect all TGBs with the TMGB with the telecommunications backbone conductor. If more than one TMGB is installed, interconnect TMGBs using the grounding equalizer conductor. The telecommunications backbone conductor and grounding equalizer conductor size shall not be less than 2 kcmils/linear foot (1 sq. mm/linear meter) of conductor length, up to a maximum size of No. 3/0 AWG 168 kcmils (85 sq. mm) unless otherwise indicated.

F. Telecommunications Enclosures and Equipment Racks: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Install top-mounted rack grounding busbar unless the enclosure and rack are manufactured with the busbar. Bond the equipment grounding busbar to the TGB No. 2 AWG bonding conductors.

G. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each TGB and TMGB to the vertical steel of the building frame.

H. Electrical Power Panelboards: Where an electrical panelboard for telecommunications equipment is located in the same room or space, bond each TGB to the ground bar of the panelboard.

I. Shielded Cable: Bond the shield of shielded cable to the TGB in communications rooms and spaces. Comply with TIA/EIA-568-B.1 and TIA/EIA-568-B.2 when grounding screened, balanced, twisted-pair cables.

J. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the cabinet or rack grounding bar. Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.

K. Access Floors: Bond all metal parts of access floors to the TGB.

L. Equipment Room Signal Reference Grid: Provide a low-impedance path between telecommunications cabinets, equipment racks, and the reference grid, using No. 6 AWG bonding conductors.

1. Install the conductors in grid pattern on 4-foot (1200-mm) centers, allowing bonding of one pedestal from each access floor tile.
2. Bond the TGB of the equipment room to the reference grid at two or more locations.
3. Bond all conduits and piping entering the equipment room to the TGB at the perimeter of the room.

M. Towers and Antennas:

1. Ground Ring: Buried at least 30 inches (760 mm) below grade and at least 24 inches (610 mm) from the base of the tower or mounting.
2. Bond each tower base and metallic frame of a dish to the ground ring, buried at least 18 inches (460 mm) below grade.
3. Bond the ground ring and antenna grounds to the equipment room TMGB or TGB, buried at least 30 inches (760 mm) below grade.
4. Bond metallic fences within 6 feet (1.8 m) of towers and antennas to the ground ring, buried at least 18 inches (460 mm) below grade.
5. Special Requirements for Roof-Mounted Towers:

    a. Roof Ring: Meet requirements for the ground ring except the conductors shall comply with requirements in Section 264113 "Lightning Protection for Structures."
    b. Bond tower base footings steel, the TGB in the equipment room, and antenna support guys to the roof ring.
    c. Connect roof ring to the perimeter conductors of the lightning protection system.

6. Waveguides and Coaxial Cable:

    a. Bond cable shields at the point of entry into the building to the TGB and to the cable entrance plate, using No. 2 AWG bonding conductors.
    b. Bond coaxial cable surge arrester to the ground or roof ring using bonding conductor size recommended by surge-arrester manufacturer.

N. Grounding of all technology components must also meet Motorola’s R-56 grounding standards.

3.7 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.

B. Comply with IEEE C2 grounding requirements.

C. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) extends above

finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, nonshrink grout.

D. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect grounding conductors to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

3.8 IDENTIFICATION

A. Labels shall be preprinted or computer-printed type.

1. Label TMGB(s) with "fs-TMGB," where "fs" is the telecommunications space identifier for the space containing the TMGB.
2. Label TGB(s) with "fs-TGB," where "fs" is the telecommunications space identifier for the space containing the TGB.
3. Label the BCT and each telecommunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

3.9 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
2. Test the bonding connections of the system using an ac earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing a TMGB and a TGB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.

    a. Measure the resistance between the busbar and the nearest available grounding electrode. The maximum acceptable value of this bonding resistance is 100 milliohms.

3. Test for ground loop currents using a digital clamp-on ammeter, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.

    a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the TMGB and in each TGB. Maximum acceptable ac current level is 1 A.

D. Excessive Ground Resistance: If resistance to ground at the BCT exceeds 5 ohms, notify Architect promptly and include recommendations to reduce ground resistance.

E. Grounding system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 270526

SECTION 270528

PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Optical-fiber-cable pathways and fittings.
4. Metal wireways and auxiliary gutters.
5. Nonmetallic wireways and auxiliary gutters.
6. Surface pathways.
7. Boxes, enclosures, and cabinets.
8. Handholes and boxes for exterior underground cabling.

B. Related Requirements:

1. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
2. Section 260533 "Raceways and Boxes for Electrical Systems" for conduits, wireways, surface raceways, boxes, enclosures, cabinets, handholes, and faceplate adapters serving electrical systems.
3. Section 280528 "Pathways for Electronic Safety and Security" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving electronic safety and security.

1.3 DEFINITIONS

A. ARC: Aluminum rigid conduit.

B. GRC: Galvanized rigid steel conduit.

C. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

A. Product Data: For surface pathways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

D. Samples: For wireways, nonmetallic wireways, and surface pathways and for each color and texture specified, 12 inches (300 mm)] 120 inches (3000 mm) long.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Pathway routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of pathway groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Qualification Data: For professional engineer.

C. Seismic Qualification Certificates: For pathway racks, enclosures, cabinets, equipment racks and their mounting provisions, including those for internal components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which certification is based and their installation requirements.
4. Detailed description of conduit support devices and interconnections on which certification is based and their installation requirements.

D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. AFC Cable Systems, Inc.
2. Allied Tube & Conduit.
3. Alpha Wire Company.
4. Anamet Electrical, Inc.
5. Electri-Flex Company.
6. O-Z/Gedney.
7. Picoma Industries.
8. Republic Conduit.
9. Robroy Industries.
10. Southwire Company.
11. Thomas & Betts Corporation.
12. Western Tube and Conduit Corporation.
13. Wheatland Tube Company.

B. General Requirements for Metal Conduits and Fittings:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. ARC: Comply with ANSI C80.5 and UL 6A.

E. IMC: Comply with ANSI C80.6 and UL 1242.

F. PVC-Coated Steel Conduit: PVC-coated [rigid steel conduit] [IMC].

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch (1 mm), minimum.

G. EMT: Comply with ANSI C80.3 and UL 797.

H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
2. Fittings for EMT:

a. Material: Steel or die cast.
b. Type: Compression.

3. Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions where installed, and including flexible external bonding jumper.
4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

I. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. AFC Cable Systems, Inc.
2. Allied Tube & Conduit.
3. Anamet Electrical, Inc.
4. Arnco Corporation.
5. CANTEX Inc.
6. CertainTeed Corporation.
7. Condux International, Inc.
8. Electri-Flex Company.
9. Kraloy.
10. Lamson & Sessions; Carlon Electrical Products.
11. Niedax-Kleinhuis USA, Inc.
12. RACO; Hubbell.
13. Thomas & Betts Corporation.

B. General Requirements for Nonmetallic Conduits and Fittings:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

C. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

D. Rigid HDPE: Comply with UL 651A.

E. Continuous HDPE: Comply with UL 651B.

F. RTRC: Comply with UL 1684A and NEMA TC 14.

G. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

H. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

I. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 OPTICAL-FIBER-CABLE PATHWAYS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Alpha Wire Company.
2. Arnco Corporation.
3. Endot Industries Inc.
4. IPEX.
5. Lamson & Sessions; Carlon Electrical Products.

B. Description: Comply with UL 2024; flexible-type pathway, approved for plenum, riser, or general-use installation unless otherwise indicated.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

2.4 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cooper B-Line, Inc.
2. Hoffman.
3. Mono-Systems, Inc.
4. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Hinged type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.5 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Allied Moulded Products, Inc.
2. Hoffman.
3. Lamson & Sessions; Carlon Electrical Products.
4. Niedax-Kleinhuis USA, Inc.

B. General Requirements for Nonmetallic Wireways and Auxiliary Gutters:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

C. Description: Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover shall be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections shall be flanged and have stainless-steel screws and oil-resistant gaskets.

D. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.

E. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.

F. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

G. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6 SURFACE PATHWAYS

A. General Requirements for Surface Pathways:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

B. Surface Metal Pathways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Mono-Systems, Inc.
b. Niedax-Kleinhuis USA, Inc.
c. Panduit Corp.
d. Wiremold / Legrand.

C. Surface Nonmetallic Pathways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors. Product shall comply with UL-94 V-0 requirements for self-extinguishing characteristics.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Lamson & Sessions; Carlon Electrical Products.
b. Mono-Systems, Inc.
c. Panduit Corp.
d. Quazite:Hubbell Power Systems, Inc.
e. Wiremold / Legrand.

D. Tele-Power Poles:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Mono-Systems, Inc.
b. Panduit Corp.
c. Wiremold / Legrand.

2. Material: Aluminum with clear anodized finish.

3. Fittings and Accessories: Dividers, end caps, covers, cutouts, wiring harnesses, devices, mounting materials, and other fittings shall match and mate with tele-power pole as required for complete system.

2.7 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Adalet.
2. Cooper Technologies Company; Cooper Crouse-Hinds.
3. EGS/Appleton Electric.
4. Erickson Electrical Equipment Company.
5. Hoffman.
6. Lamson & Sessions; Carlon Electrical Products.
7. Milbank Manufacturing Co.
8. Molex; Woodhead Brand.
9. Mono-Systems, Inc.
10. O-Z/Gedney.
11. Quazite:Hubbell Power Systems, Inc.
12. RACO; Hubbell.
13. Robroy Industries.
14. Spring City Electrical Manufacturing Company.
15. Stahlin Non-Metallic Enclosures.
16. Thomas & Betts Corporation.
17. Wiremold / Legrand.

B. General Requirements for Boxes, Enclosures, and Cabinets:

1. Comply with TIA-569-B.
2. Boxes, enclosures and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet-Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.

E. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

F. Metal Floor Boxes:

1. Material: Cast metal or sheet metal.
2. Type: Fully adjustable.
3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Nonmetallic Floor Boxes: Nonadjustable, rectangular.

1. Listing and Labeling: Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

I. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum or galvanized, cast iron with gasketed cover.

J. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep).

K. Gangable boxes are allowed.

L. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

M. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures:

a. Material: Fiberglass.
b. Finished inside with radio-frequency-resistant paint.

3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

N. Cabinets:

1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.8 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND CABLING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Comply with TIA-569-B.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Armorcast Products Company.
    b. Carson Industries LLC.
    c. NewBasis.
    d. Oldcastle Precast, Inc; Christy Concrete Products.
    e. Quazite: Hubbell Power System, Inc; Hubbell Power Systems.
    f. Synertech Moulded Products.

3. Standard: Comply with SCTE 77.
4. Configuration: Designed for flush burial with closed integral closed bottom unless otherwise indicated.
5. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
6. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
7. Cover Legend: Molded lettering, "COMMUNICATIONS.".
8. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
9. Handholes 12 Inches Wide by 24 Inches Long (300 mm Wide by 600 mm Long) and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

C. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of cast iron.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Armorcast Products Company.
    b. Carson Industries LLC.
    c. NewBasis.
    d. Nordic Fiberglass, Inc.
    e. Oldcastle Precast, Inc; Christy Concrete Products.
    f. Quazite: Hubbell Power System, Inc; Hubbell Power Systems.
    g. Synertech Moulded Products.

3. Standard: Comply with SCTE 77.
4. Color of Frame and Cover: Gray.

5. Configuration: Designed for flush burial with closed bottom unless otherwise indicated.
6. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
7. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
8. Cover Legend: Molded lettering, "COMMUNICATIONS.".
9. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
10. Handholes 12 Inches Wide by 24 Inches Long (300 mm Wide by 600 mm Long) and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.9 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 PATHWAY APPLICATION

A. Outdoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
2. Concealed Conduit, Aboveground: GRC.
3. Underground Conduit: RNC, concrete encased.
4. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.

B. Indoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT or RNC.
2. Exposed, Not Subject to Severe Physical Damage: EMT or RNC identified for such use.
3. Exposed and Subject to Severe Physical Damage: [GRC] [IMC]. Pathway locations include the following:

a. Loading dock.
b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
c. Mechanical rooms.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT, RNC, Type EPC-40-PVC or innerduct.
5. Damp or Wet Locations: GRC.
6. Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical-fiber-cable pathway.
7. Pathways for Optical-Fiber or Communications-Cable Risers in Vertical Shafts: Riser-type, optical-fiber-cable pathway.
8. Pathways for Concealed General-Purpose Distribution of Optical-Fiber or Communications Cable: Plenum-type, optical-fiber-cable pathway.
9. Boxes and Enclosures: NEMA 250 Type 1, except use NEMA 250 Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Pathway Size: 3/4-inch (21-mm) trade size. Minimum size for optical-fiber cables is 1 inch (27 mm).

D. Pathway Fittings: Compatible with pathways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use setscrew or compression, cast-metal fittings. Comply with NEMA FB 2.10.

E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

F. Install surface pathways only where indicated on Drawings.

G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F (49 deg C).

3.2 INSTALLATION

A. Comply with NECA 1, NECA 101, and TIA-569-B for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum pathways. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.

B. Keep pathways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.

C. Complete pathway installation before starting conductor installation.

D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

E. Arrange stub-ups so curved portions of bends are not visible above finished slab.

F. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches (300 mm) of changes in direction. Utilize long radius ells for all optical-fiber cables.

G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

H. Support conduit within 12 inches (300 mm) of enclosures to which attached.

I. Pathways Embedded in Slabs:

1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10-foot (3-m) intervals.
2. Arrange pathways to cross building expansion joints at right angles with expansion fittings.
3. Arrange pathways to keep a minimum of 1 inch (25 mm)] [2 inches (50 mm) of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
5. Change from ENT to RNC, Type EPC-40-PVC, GRC or IMC before rising above floor.

J. Stub-ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for pathways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

K. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound manufacturer's written instructions.

L. Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.

M. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.

N. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

O. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

P. Cut conduit perpendicular to the length. For conduits of 2-inch (53-mm) trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.

Q. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg)tensile strength. Leave at least 12 inches (300 mm)of slack at each end of pull wire. Cap underground pathways designated as spare above grade alongside pathways in use.

R. Surface Pathways:

1. Install surface pathway for surface telecommunications outlet boxes only where indicated on Drawings.
2. Install surface pathway with a minimum 2-inch (50-mm) radius control at bend points.
3. Secure surface pathway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight pathway section. Support surface pathway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

S. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:

1. 3/4-Inch (21-mm) Trade Size and Smaller: Install pathways in maximum lengths of 50 feet (15 m).
2. 1-Inch (27-mm) Trade Size and Larger: Install pathways in maximum lengths of 75 feet (23 m).
3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

T. Install pathway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install pathway sealing fittings according to NFPA 70.

U. Install devices to seal pathway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service pathway enters a building or structure.
3. Where otherwise required by NFPA 70.

V. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.

W. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC[and EMT] conduit that is located where environmental temperature change may exceed 100 deg F (55 deg C) and that has straight-run length that exceeds 100 feet (30 m).
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
    d. Attics: 135 deg F (75 deg C) temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F (0.0115 mm per meter of length of straight run per deg C) of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

X. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to top of box unless otherwise indicated.

Y. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

Z. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

AA. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

BB. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

CC. Set metal floor boxes level and flush with finished floor surface.

DD. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.
2. Install backfill as specified in Section 312000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete for a minimum of 12 inches (300 mm) on each side of the coupling.
    b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

6. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried conduits, but a minimum of 6 inches (150 mm) below grade. Align planks along centerline of conduit.
7. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.

D. Install handholes with bottom below frost line, below grade.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.

F. Field cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

3.6 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.7 PROTECTION

A. Protect coatings, finishes, and cabinets from damage or deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 270528

SECTION 270536

CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Ladder cable trays.
2. Wire-basket cable trays.
3. Single-rail cable trays.
4. Trough cable trays.
5. Fiberglass cable trays.

B. Related Requirements:

1. Section 260536 "Cable Trays for Electrical Systems" for cable trays and accessories serving electrical systems.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of cable tray.

1. Include data indicating dimensions and finishes for each type of cable tray indicated.

B. Shop Drawings: For each type of cable tray.

1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.

C. Delegated-Design Submittal: For seismic restraints.

1. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.

2. Design Calculations: Calculate requirements for selecting seismic restraints.
3. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Include scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements.
2. Vertical and horizontal offsets and transitions.
3. Clearances for access above and to side of cable trays.
4. Vertical elevation of cable trays above the floor or below bottom of ceiling structure.

B. Seismic Qualification Certificates: For cable trays, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cable tray supports and seismic bracing.

B. Seismic Performance: Cable trays and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the cable trays will remain in place without separation of any parts when subjected to the seismic forces specified."
2. Component Importance Factor: 1.0.

C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes in cable tray installed outdoors.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 GENERAL REQUIREMENTS FOR CABLE TRAYS

A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.

1. Source Limitations: Obtain cable trays and components from single manufacturer.

B. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.

C. Structural Performance: See articles for individual cable tray types for specific values for the following parameters:

1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
2. Concentrated Load: A load applied at midpoint of span and centerline of tray.
3. Load and Safety Factors: Applicable to both side rails and rung capacities.

2.3 LADDER CABLE TRAYS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Allied Tube & Conduit; a Tyco International Ltd. Co.
2. Chalfant Manufacturing Company.
3. Cooper B-Line, Inc.
4. Mono-Systems, Inc.
5. MP Husky.
6. Niedax-Kleinhuis USA, Inc.
7. Chatsworth Inc.

C. Description:

1. Configuration: Two I-beam side rails with transverse rungs welded to side rails.
2. Rung Spacing: 12 inches (300 mm) o.c.
3. Radius-Fitting Rung Spacing: 9 inches (225 mm) at center of tray's width.
4. Minimum Cable-Bearing Surface for Rungs: 7/8-inch (22-mm) width with radius edges.
5. No portion of the rungs shall protrude below the bottom plane of side rails.
6. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb (90-kg) concentrated load, when tested according to NEMA VE 1.
7. Minimum Usable Load Depth: 6 inches (150 mm).

8. Straight Section Lengths: 10 feet (3 m) except where shorter lengths are required to facilitate tray assembly.
9. Width: 18 inches (450 mm) and 24 inches (600 mm) unless otherwise indicated on Drawings.
10. Fitting Minimum Radius: 24 inches (600 mm).
11. Class Designation: Comply with NEMA VE 1, Class 12B.
12. Splicing Assemblies: Bolted type using serrated flange locknuts.
13. Hardware and Fasteners: ASTM F 593 and ASTM F 594 stainless steel, Type 316.
14. Splice Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

2.4 SINGLE-RAIL CABLE TRAYS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Allied Tube & Conduit; a Tyco International Ltd. Co.
2. Cooper B-Line, Inc.
3. Mono-Systems, Inc.
4. MP Husky.
5. Chatsworth Inc

C. Description:

1. Configuration: Center rail with extruded-aluminum rungs arranged symmetrically about the center rail.
2. Construction: Aluminum rungs mechanically connected to aluminum center rail in at least two places, with ends finished to protect installers and cables.
3. Rung Spacing: 12 inches (300 mm) o.c.
4. Radius-Fitting Rung Spacing: 9 inches (225 mm) at center of tray's width.
5. Straight Section Lengths: 10 feet (3 m) except where shorter lengths are required to facilitate tray assembly.
6. Width: 18 inches (450 mm) and 24 inches (600 mm) unless otherwise indicated on Drawings.
7. Support Point: Splice fittings shall be hanger support point.
8. Support Spacing: Support each section at midpoint. Support wall-mounted sections a maximum of one-sixth of the section length from each end.
9. Loading Depth: 6 inches (150 mm).
10. Maximum Loads: 50 lb/ft. (74 kg/m).
11. Unbalanced Loads: Maintain cable tray rungs within six degrees of horizontal under all loading conditions.
12. Splicing Assemblies: Bolted type using serrated flange locknuts.
13. Splicing Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

14. Hardware and Fasteners: ASTM F 593 and ASTM F 594 stainless steel, Type 316.
15. Splices and Connectors: Protect cables from edges of center rail and do not intrude into cable fill area.

2.5 TROUGH CABLE TRAYS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Allied Tube & Conduit; a Tyco International Ltd. Co.
2. Chalfant Manufacturing Company.
3. Cooper B-Line, Inc.
4. Mono-Systems, Inc.
5. MP Husky.
6. Niedax-Kleinhuis USA, Inc.
7. Chatsworth Inc.

C. Description:

1. Configuration: Two longitudinal members (side rails) with a solid sheet over rungs exposed on the interior of the trough, or corrugated sheet with both edges welded to the side rails.
2. Rung Spacing: Rungs or corrugations shall be spaced a maximum of 6 inches (150 mm) o.c. and have a minimum flat bearing surface of 2 inches (50 mm).
3. Radius-Fitting Rung Spacing: 9 inches (225 mm) at center of tray's width.
4. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a200-lb (90-kg) concentrated load, when tested according to NEMA VE 1.
5. Minimum Usable Load Depth: 6 inches (150 mm).
6. Straight Section Lengths: 10 feet (3 m) except where shorter lengths are required to facilitate tray assembly.
7. Width: 18 inches (450 mm) and 24 inches (600 mm) unless otherwise indicated on Drawings.
8. Fitting Minimum Radius: 24 inches (600 mm).
9. Class Designation: Comply with NEMA VE 1, Class 12B.
10. Splicing Assemblies: Bolted type using serrated flange locknuts.
11. Splicing Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
12. Hardware and Fasteners: ASTM F 593 and ASTM F 594 stainless steel, Type 316.

2.6 MATERIALS AND FINISHES

A. Steel:

1. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A 1011/A 1011M, SS, Grade 33.
2. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
3. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
4. Finish: Mill galvanized before fabrication.

    a. Standard: Comply with ASTM A 653/A 653M, G90 (Z275).
    b. Hardware: Galvanized, ASTM B 633.

5. Finish: Electrogalvanized before fabrication.

    a. Standard: Comply with ASTM B 633.
    b. Hardware: Galvanized, ASTM B 633.

6. Finish: Hot-dip galvanized after fabrication.

    a. Standard: Comply with ASTM A 123/A 123M, Class B2.
    b. Hardware: Chromium-zinc plated, ASTM F 1136.

7. Finish: Powder-coat enamel paint.

    a. Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
    b. Epoxy-Resin Prime Coat: Cold-curing epoxy primer, MPI# 101.
    c. Epoxy-Resin Topcoat: Epoxy, cold-cured, gloss, MPI# 77.
    d. Hardware: Chromium-zinc plated, ASTM F 1136.

8. Finish: Factory-standard primer, ready for field painting, with chromium-zinc-plated hardware according to ASTM F 1136.
9. Finish: Black oxide finish for support accessories and miscellaneous hardware according to ASTM D 769.

B. Aluminum:

1. Materials: Alloy 6063-T6 according to ANSI H 35.1/H 35.1M for extruded components and Alloy 5052-H32 or Alloy 6061-T6 according to ANSI H 35.1/H 35.1M for fabricated parts.
2. Hardware: Chromium-zinc-plated steel, ASTM F 1136.
3. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F 593 and ASTM F 594.

C. Stainless Steel:

1. Materials: Low-carbon, passivated, stainless steel, Type 304L or Type 316L, ASTM F 593 and ASTM F 594.

2. Hardware for Stainless-Steel Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F 593 and ASTM F 594.

2.7 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Covers: Louvered type made of same materials and with same finishes as cable tray.

C. Barrier Strips: Same materials and finishes as for cable tray.

D. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.8 WARNING SIGNS

A. Lettering: 1-1/2-inch- (40-mm-) high, black letters on yellow background with legend "Warning! Not To Be Used as Walkway, Ladder, or Support for Ladders or Personnel."

B. Comply with requirements for fasteners in Section 260553 "Identification for Electrical Systems."

2.9 SOURCE QUALITY CONTROL

A. Testing: Test and inspect cable trays according to NEMA FG 1.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

A. Install cable trays according to NEMA FG 1.

B. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.

C. Install cable trays so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.

D. Remove burrs and sharp edges from cable trays.

E. Join aluminum cable tray with splice plates; use four square neck-carriage bolts and locknuts.

F. Fasten cable tray supports to building structure.

G. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of 200 lb (90 kg). Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems."

H. Place supports so that spans do not exceed maximum spans on schedules and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.

I. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.

J. Support bus assembly to prevent twisting from eccentric loading.

K. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.

L. Locate and install supports according to NEMA FG 1. Do not install more than one cable tray splice between supports.

M. Support wire-basket cable trays with trapeze hangers.

N. Support trapeze hangers for wire-basket trays with 3/8-inch- (10-mm-) diameter rods.

O. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.

P. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA FG 1. Space connectors and set gaps according to applicable standard.

Q. Make changes in direction and elevation using manufacturer's recommended fittings.

R. Make cable tray connections using manufacturer's recommended fittings.

S. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 078413 "Penetration Firestopping."

T. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

U. Install cable trays with enough workspace to permit access for installing cables.

V. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.

W. Install permanent covers, if used, after installing cable. Install cover clamps according to NEMA VE 2.

X. Clamp covers on cable trays installed outdoors with heavy-duty clamps.

Y. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.2 CABLE TRAY GROUNDING

A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Cable trays with communications cable shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

C. Cable trays with control conductors shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

D. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.

E. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

3.3 CABLE INSTALLATION

A. Install cables only when each cable tray run has been completed and inspected.

B. Fasten cables on horizontal runs with cable clamps or cable ties according to NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.

C. Fasten cables on vertical runs to cable trays every 18 inches (450 mm).

D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches (1800 mm).

E. Tie MI cables down every 36 inches (900 mm) where required to provide a 2-hour fire rating and every 72 inches (1800 mm) elsewhere.

F. In existing construction, remove inactive or dead cables from cable trays.

3.4 CONNECTIONS

A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.

B. Connect pathways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
4. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
7. Check for improperly sized or installed bonding jumpers.
8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

3.6 PROTECTION

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION 270536

SECTION 270544

SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS AND CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Sleeves for pathway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

1. Cables passing through fire-rated floors or walls shall pass through fire-rated wiring devices which contain an intumescent insert material that adjusts automatically to cable additions or subtractions.

2. The device (per code requirements) shall include both internal and external fire-stopping.

3. Cables penetrating through fire-rated floors or walls shall utilize fire-rated pathway devices capable of providing an F rating equal to the rating of the barrier in which the device is installed.

4. The device shall be tested for smoke leakage (L rating) and shall not require the use of any optional sealing materials to achieve the published rating.

5. The device shall utilize a fire and smoke sealing system that automatically adjusts to the addition or removal of cables.

6. Wiring devices shall be capable of allowing a 0 to 100-percent visual fill of cables.

7. Wire devices shall be of a sufficient size to accommodate the quantity and size of electrical wires and data cables required and shall be suitable for use with new or existing cable installations.

8. The installed device (in normal use) shall require no maintenance and shall accommodate future cable changes without mechanical adjustment and/or removal or replacement of protective materials.

9. Wire devices to be provided with steel wall plates allowing for single or multiple devices to be ganged together.

10. The device shall be modular and shall provide mechanical installation options for common wall and floor constructions as well as common construction conditions including over-sized or damaged openings or existing sleeves.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include and are limited to the following:

b. Specified Technologies, Inc.

2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by the following:

a. Specified Technologies, Inc.
   1) EZ Path Fire Rated Pathway

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

   a. Specified Technologies, Inc.

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
2. Sealant shall have VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

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

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Comply with manufacturer's recommended installation proceedures.

D. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

    a. Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
    b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pathway or cable unless sleeve seal is to be installed.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level. Install sleeves during erection of floors.

E. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

F. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.

G. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

H. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between pathway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at pathway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 270544

SECTION 28 31 00

FIRE DETECTION AND ALARM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Nonsystem smoke detectors.
5. Heat detectors.
6. Notification appliances.
7. Magnetic door holders.
8. Remote annunciator.
9. Addressable interface device.
10. Digital alarm communicator transmitter.

B. Related Requirements:

1. Section 21 00 00 "Fire Protection Systems" for additional responsibilities.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.

B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.

11. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.

    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Show field wiring required for HVAC unit shutdown on alarm.
    c. Locate detectors according to manufacturer's written recommendations.

12. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

C. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:

    a. Trained and certified by manufacturer in fire-alarm system design.
    b. NICET-certified, fire-alarm technician; **Level IV** minimum.
    c. Licensed or certified by authorities having jurisdiction.

D. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.

C. Field quality-control reports.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following **and deliver copies to authorities having jurisdiction**:

a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
c. Complete wiring diagrams showing connections between all devices and equipment.
d. Riser diagram.
e. Record copy of site-specific software.
f. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

1) Equipment tested.
2) Frequency of testing of installed components.
3) Frequency of inspection of installed components.
4) Requirements and recommendations related to results of maintenance.
5) Manufacturer's user training manuals.

g. Manufacturer's required maintenance related to system warranty requirements.
h. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm **Level IV** technician.

C. NFPA Certification: Obtain certification according to NFPA 72 by an NRTL (nationally recognized testing laboratory).

D. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

E. NFPA Certification: Obtain certification according to NFPA 72 in the form of a placard by an FM Global-approved alarm company.

F. NFPA Certification: Obtain certification according to NFPA 72 by local Fire Marshal.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
2. Warranty Period: **Five** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with, and operate as an extension of, existing system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.

B. Noncoded, **UL-certified** addressable system, with multiplexed signal transmission and horn/strobe evacuation.

C. Automatic sensitivity control of certain smoke detectors.

D. All components provided shall be listed for use with the selected system and shall be able to communicate to the BAS via BACNet protocol.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices **and systems**:

1. Manual stations.

2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Carbon monoxide detectors.
6. Automatic sprinkler system water flow.
7. Fire-extinguishing system operation.
8. Fire standpipe system.
9. Dry system pressure flow switch.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm and specific initiating device at fire-alarm control unit **and remote annunciators**.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
7. Close smoke dampers in air ducts of designated air-conditioning duct systems.
8. Activate preaction system.
9. Recall elevators to primary or alternate recall floors.
10. Activate elevator power shunt trip.
11. Activate emergency lighting control.
12. Activate emergency shutoffs for gas and fuel supplies.
13. Record events in the system memory.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. High- or low-air-pressure switch of a dry-pipe or preaction sprinkler system.
3. Elevator shunt-trip supervision.
4. Loss of communication with any panel on the network.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, or remote annunciator.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.

E. System Supervisory Signal Actions:

1. Initiate notification appliances.
2. Identify specific device initiating the event at fire-alarm control unit **and remote annunciators**.
3. After a time delay of **200 seconds**, transmit a trouble or supervisory signal to the remote alarm receiving station.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to **ASCE/SEI 7**.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified **and the unit will be fully operational after the seismic event**."

2.4 FIRE-ALARM CONTROL UNIT

A. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:

B. Basis-of-Design Product: Subject to compliance with requirements, provide **product indicated on Drawings** or comparable product by one of the following:
1. Fike Corporation.
2. Fire-Lite Alarms.
3. GAMEWELL.
4. GE UTC Fire & Security; A United Technologies Company.
5. Notifier.
6. Siemens Industry, Inc.; Fire Safety Division.
7. Silent Knight.
8. SimplexGrinnell LP.

C. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.
2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.

D. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, **80** characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.

E. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1. Pathway Class Designations: NFPA 72, [**Class B**] [**Class D**] [**Class E**].
2. Pathway Survivability: [**Level 0**] [**Level 1**].

F. Notification-Appliance Circuit:

1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
2. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

G. Elevator Recall:

1. Elevator recall shall be initiated only by one of the following alarm-initiating devices:

    a. Elevator lobby detectors except the lobby detector on the designated floor.
    b. Smoke detector in elevator machine room.
    c. Smoke detectors in elevator hoistway.

2. Elevator controller shall be programmed to move the cars to the alternate recall floor if lobby detectors located on the designated recall floors are activated.
3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.

    a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

H. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls shall [**be**] [**not be**] connected to fire-alarm system.

I. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory.

J. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

K. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, [**supervisory signals**] [**supervisory and digital alarm communicator transmitters**] [**and**] [**digital alarm radio transmitters**] shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

L. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

2.5 MANUAL FIRE-ALARM BOXES

A. Manufacturers: Subject to compliance with requirements, [**provide products by the following**] [**provide products by one of the following**] [**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:

B. Basis-of-Design Product: Subject to compliance with requirements, provide [**product indicated on Drawings**] <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:
1. Cooper Wheelock.
2. Federal Signal Corporation.
3. Fike Corporation.
4. Fire-Lite Alarms.
5. GAMEWELL.
6. GE UTC Fire & Security; A United Technologies Company.
7. Notifier.
8. Siemens Industry, Inc.; Fire Safety Division.
9. Silent Knight.
10. SimplexGrinnell LP.
11. System Sensor.

C. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38.

1. Single-action mechanism, [**breaking-glass or plastic-rod**] [**pull-lever**] type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.

2.6 SYSTEM SMOKE DETECTORS

A. Manufacturers: Subject to compliance with requirements, [**provide products by the following**] [**provide products by one of the following**] [**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:

B. Basis-of-Design Product: Subject to compliance with requirements, provide [**product indicated on Drawings**] <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:

1. Bosch Security Systems.
2. Faraday.
3. Fenwal Protection Systems; A UTC Fire & Security Company.

4. Fire-Lite Alarms.
5. GAMEWELL.
6. GE UTC Fire & Security; A United Technologies Company.
7. Gentex Corporation.
8. Harrington Signal, Inc.
9. Keltron Corporation.
10. Mircom Technologies, Ltd.
11. Notifier.
12. Siemens Industry, Inc.; Fire Safety Division.
13. Silent Knight.
14. SimplexGrinnell LP.
15. System Sensor.

C. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be [**four**] [**two**]-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type, indicating detector has operated[**and power-on status**].
7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition[**and individually adjustable for sensitivity by fire-alarm control unit**].

    a. Rate-of-rise temperature characteristic of combination smoke- and heat-detection units shall be selectable at fire-alarm control unit for 15 or 20 deg F (8 or 11 deg C) per minute.
    b. Fixed-temperature sensing characteristic of combination smoke- and heat-detection units shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F (57 or 68 deg C).
    c. Multiple levels of detection sensitivity for each sensor.
    d. Sensitivity levels based on time of day.

D. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.

d. Present sensitivity selected.
e. Sensor range (normal, dirty, etc.).

E. Ionization Smoke Detector:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

a. Primary status.
b. Device type.
c. Present average value.
d. Present sensitivity selected.
e. Sensor range (normal, dirty, etc.).

F. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

a. Primary status.
b. Device type.
c. Present average value.
d. Present sensitivity selected.
e. Sensor range (normal, dirty, etc.).

3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
6. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

2.7 CARBON MONOXIDE DETECTORS

A. General: Carbon monoxide detector listed for connection to fire-alarm system.

1. Mounting: Adapter plate for outlet box mounting.
2. Testable by introducing test carbon monoxide into the sensing cell.
3. Detector shall provide alarm contacts and trouble contacts.
4. Detector shall send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
5. Comply with UL 2075.
6. Locate, mount, and wire according to manufacturer's written instructions.
7. Provide means for addressable connection to fire-alarm system.
8. Test button simulates an alarm condition.

2.8 NONSYSTEM SMOKE DETECTORS

A. General Requirements for Nonsystem Smoke Detectors:

1. Nonsystem smoke detectors shall be listed as compatible with the fire-alarm equipment installed or shall have a contact closure interface listed for the connected load.
2. Nonsystem smoke detectors shall meet the monitoring for integrity requirements in NFPA 72.

B. Single-Station Smoke Detectors:

1. Comply with UL 217; suitable for NFPA 101, residential occupancies; operating at 120-V ac[**with 9-V dc battery as the secondary power source. Provide with "low" or "missing" battery chirping-sound device**].
2. Auxiliary Relays: One [**Form C, rated at 0.5 A**] [**Form A and one Form C, both rated at 0.5 A**].
3. Audible Notification Appliance: Piezoelectric sounder rated at 90 dBA at 10 feet (3 m) according to UL 464.
4. Visible Notification Appliance: 177-cd strobe.
5. Heat sensor, 135 deg F (57 deg C) [**combination rate-of-rise and**]fixed temperature.
6. Test Switch: Push to test; simulates smoke at rated obscuration.
7. Tandem Connection: Allow tandem connection of number of indicated detectors; alarm on one detector shall actuate notification on all connected detectors.
8. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
9. Self-Restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.
10. Integral Visual-Indicating Light: LED type, indicating detector has operated[**and power-on status**].

C. Single-Station Duct Smoke Detectors:

1. Comply with UL 268A; operating at 120-V ac.
2. Sensor: LED or infrared light source with matching silicon-cell receiver.

    a. Detector Sensitivity: Smoke obscuration between 2.5 and 3.5 percent/foot (0.008 and 0.011 percent/mm) when tested according to UL 268A.

3. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. The fixed base shall be designed for mounting directly to air duct. Provide terminals in the fixed base for connection to building wiring.

    a. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; listed for use with the supplied detector.

4. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.

5. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2.9 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

1. Temperature sensors shall test for and communicate the sensitivity range of the device.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature or a rate of rise.

1. Mounting: [**Adapter plate for outlet box mounting**] [**Twist-lock base interchangeable with smoke-detector bases**].
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

C. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature.

1. Mounting: [**Adapter plate for outlet box mounting**] [**Twist-lock base interchangeable with smoke-detector bases**].
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.10 NOTIFICATION APPLIANCES

A. Manufacturers: Subject to compliance with requirements, [**provide products by the following**] [**provide products by one of the following**] [**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:

B. Basis-of-Design Product: Subject to compliance with requirements, provide [**product indicated on Drawings**] **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

1. Cooper Wheelock.
2. Federal Signal Corporation.
3. GE UTC Fire & Security; A United Technologies Company.
4. Gentex Corporation.
5. Harrington Signal, Inc.
6. Keltron Corporation.
7. Mircom Technologies, Ltd.
8. Siemens Industry, Inc.; Fire Safety Division.
9. SimplexGrinnell LP.
10. System Sensor.

C. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

D. Chimes: Vibrating type.

E. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464.

F. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.

1. Mounting: Wall mounted unless otherwise indicated.
2. Flashing shall be in a temporal pattern, synchronized with other units.
3. Strobe Leads: Factory connected to screw terminals.
4. Mounting Faceplate: Factory finished, [**red**] [**white**].

2.11 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnets: Require no more than 3 W to develop 25-lbf (111-N) holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24-V ac or dc.
4. Rating: 120-V ac.

B. Material and Finish: Match door hardware.

2.12 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: [**Flush**] cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.13 ADDRESSABLE INTERFACE DEVICE

A. General:

1. Include address-setting means on the module.
2. Store an internal identifying code for control panel use to identify the module type.
3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Integral Relay: Capable of providing a direct signal [**to elevator controller to initiate elevator recall**] [**to circuit-breaker shunt trip for power shutdown**]

1. Allow the control panel to switch the relay contacts on command.
2. Have a minimum of two normally open and two normally closed contacts available for field wiring.

D. Control Module:

1. Operate notification devices.
2. Operate solenoids for use in sprinkler service.

2.14 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture [**one**] [**two**] telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Verification that both telephone lines are available.
2. Programming device.
3. LED display.
4. Manual test report function and manual transmission clear indication.
5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.
2. Address of the supervisory signal.
3. Address of the trouble-initiating device.
4. Loss of ac supply.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.
8. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.

C. Equipment Mounting: Install fire-alarm control unit on finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Install wall-mounted equipment, with tops of cabinets not more than 78 inches (1980 mm) above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches (1520 mm) of the exit doorway.
2. Mount manual fire-alarm box on a background of a contrasting color.
3. The operable part of manual fire-alarm box shall be between 42 inches (1060 mm) and 48 inches (1220 mm) above floor level. All devices shall be mounted at the same height unless otherwise indicated.

F. Smoke- or Heat-Detector Spacing: Comply with NFPA 72.

G. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches (9100 mm) long shall be supported at both ends.

H. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

I. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.

J. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

K. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

L. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling. Install all devices at the same height unless otherwise indicated.

M. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.2 PATHWAYS

A. Pathways above recessed ceilings and in nonaccessible locations may be routed exposed.

1. Exposed pathways located less than 96 inches (2440 mm) above the floor shall be installed in EMT.

B. Pathways shall be installed in EMT.

C. Exposed EMT shall be painted red enamel.

3.3 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches (910 mm) from

the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Smoke dampers in air ducts of designated HVAC duct systems.
2. Magnetically held-open doors.
3. Electronically locked doors and access gates.
4. Alarm-initiating connection to elevator recall system and components.
5. Alarm-initiating connection to activate emergency lighting control.
6. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
7. Supervisory connections at valve supervisory switches.
8. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
9. Supervisory connections at elevator shunt-trip breaker.
10. Supervisory connections at fire-extinguisher locations.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.5 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.6 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by [**Architect**] [**authorities having jurisdiction**]

B. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:

1. Visual Inspection: Conduct visual inspection prior to testing.

    a. Inspection shall be based on completed record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter.
    b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72;

retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

C. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

D. Fire-alarm system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

G. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.7 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for [**two**] years.

C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within [**two**] years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least [**30**] days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION 283111

SECTION 32 31 19

ORNAMENTAL FENCES AND SWING GATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Heavy industrial aluminum ornamental fence system.

B. Work Includes:
   1. The Contractor shall provide all labor, materials and appurtenances necessary for installation of the industrial aluminum ornamental fence system defined herein.

C. Performance Requirements:
   1. Fence system shall be designed to resist a single concentrated load of 200 pounds applied in any direction at any point on the horizontal rail(s) and to transfer this load through the supports to the structure. All fence systems shall be designed to resist a uniform load of 50 pounds per foot applied in any direction along the horizontal rail(s). This uniform load need not be assumed to act concurrently with the 200 pound concentrated load.

D. Related Sections:
   1. Section 05 50 00- Metal Fabrications, for steel framed trash enclosure gates.
   2. Section 32 31 40- Gate Operators and Control Devices, for motor operators and access control devices
   3. Section 03 30 00 Cast in Place Concrete and Section 03 41 00 Architectural Precast Concrete.

1.2 SUBMITTALS

A. Fabricator to provide engineer calculations for wind and safety load requirements.

B. Aluminum Fencing System: Manufacturer's data sheets on each product to be used, including:
   1. Preparation instructions and recommendations.
   2. Storage and handling requirements and recommendations.
   3. Installation methods

C. Shop Drawings: Indicate plan layout, spacing of components, post foundation dimensions, hardware anchorage, gates, and schedule of components.

D. Selection Samples: For each finish product specified, two complete sets of color chips representing manufacturer's full range of available colors and patterns.

E. Verification Samples: For each finish product specified, two samples, minimum size 6 inches (150mm) square, are representing actual product, color, and patterns.

F. The manufacturer's submittal package shall be provided prior to installation.

1.3 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Company specializing in manufacturing products specified in this section with minimum five years documented experience.

B. Installer Qualifications:
   1. The contractor shall provide laborers and supervisors who are thoroughly familiar with the type of construction involved and materials and techniques specified.
   2. Installer shall be experienced with type of construction involved and materials and techniques specified.
   3. Installer (subcontractor) shall have a Louisiana State Board of Contractors license.
   4. Installer shall have Louisiana State Fire's Marshalls license for Access Controls.
   5. Installer shall be a current member of the American Fence Association for minimum of three consecutive years.

C. References:
   1. ASTM B117 - Practice for Operating Salt-Spray (Fog) Apparatus.
   2. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles and Tubes.
   3. ASTM D523 - Test Method for Specular Gloss.
   4. ASTM D822 - Practice for Conducting Tests on Paint and Related Coatings and Materials using Filtered Open-Flame Carbon-Arc Light and Water Exposure Apparatus.
   5. ASTM D1654 - Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments.
   6. ASTM D2244 - Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates.
   7. ASTM D2794 - Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
   8. ASTM D3359 - Test Method for Measuring Adhesion by Tape Test.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Upon receipt at the job site, all materials shall be checked to ensure that no damage occurred during shipping or handling.

B. Materials shall be stored in such a manner to ensure proper ventilation and drainage, and be protected against damage, weather, vandalism, and theft.

1.5 PROJECT CONDITIONS

A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer’s absolute limits.

1.6 WARRANTY

A. 2 year warranty

B. The powder coated surface on all aluminum frameworks (pickets, rails, and posts) shall be warranted for 10 years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Ameristar Fence Products, Inc., of Tulsa, Oklahoma (www.ameristarfence.com). Basis of Design: Echelon II, Genesis, 2-rail-style heavy industrial aluminum ornamental fence system.

B. Elite Fence Products, Inc. of Chesterfield Twp., MI (www.elitefence.com).

C. Ideal Aluminum Products of St. Augustine, FL (www.ideal-ap.com).

2.2 MATERIALS

A. Aluminum material for fence framework (i.e., tubular pickets, rails and posts) shall conform to the requirements of ASTM B221. The aluminum extrusions for posts and rails shall be Alloy and Temper Designation 6005-T52. The aluminum extrusions for pickets shall be Alloy and Temper Designation 6063-T52. Aluminum 6063-T6 Pipe and Tube. ASTM 429.

B. Material for fence pickets shall be 1" square x 0.062" thick extruded tubing. The cross-sectional shape of the rails shall conform to Ameristar's "ForeRunner™" design with outside cross-section dimensions of 1.75" square. The top wall and internal web of the rail shall be 0.070" thick; the sidewalls shall be 0.070" thick. Picket holes in the rail shall be spaced 4.715" o.c. Picket retaining rods shall be 0.125" diameter galvanized steel. Fence posts and gate posts shall meet the minimum size requirements of Table 1. High quality PVC grommets shall be supplied to seal all picket-to-rail intersections.

C. Bracket to rail attachments shall be made using one-way tamperproof security nuts with carriage bolt. Bracket to post connections shall be made using self-drilling hex-head screws.

Table 1 – Minimum Sizes for Fence Posts

Fence Posts	Panel Height
2-1/2" x 2-1/2" x .080" Alum. w/ reinforced web	Up to & Including 6' Height
3" x 3" x .120" Alum.	Over 6' Up to & Including 8' Height
4" x 4" x .250" Alum.	Over 8' Height Up to 10'

Gate Leaf	Gate Height			
	Up to & Including 4'	Over 4' Up to & Including 6'	Over 6' Up to & Including 8'	Over 8' Up to & Including 10'
Up to 4'	3" x 3" x .120" Alum.	4" x 4" x .250 Alum. or 3" x 12 Ga. steel	4" x 11 Ga. steel	4" x 11 Ga. steel
4'1" to 6'	4" x 4" x .250 Alum. or 3" x 12Ga. steel	3" x 12 Ga. steel	4" x 11 Ga. steel	4" x 11 Ga. steel
6'1" to 8'	4" x 11 Ga. steel	4" x 11 Ga. steel	4" x 11 Ga. steel	6" x 3/16" steel
8'1" to 10'	4" x 11 Ga. steel	4" x 11 Ga. steel	6" x 3/16" steel	6" x 3/16" steel
10'1" to 12'	4" x 11 Ga. steel	6" x 3/16" steel	6" x 3/16" steel	6" x 3/16" steel
12'1" to 14'	6" x 3/16" steel	6" x 3/16" steel	6" x 3/16" steel	6" x 3/16" steel

D. Non-expansive Structural Grouting Material: Quik-Rok® Chemically Engineered Hydraulic Cement by Ameristar Fence Products.

2.3 FINISH

A. Thermal Stratification coating process (high-temperature, in-line, multi-stage, multi-layer) including six-stage pretreatment/wash with zinc phosphate, an electrostatic spray application of epoxy base, and a separate electrostatic spray application of a polyester top coat finish.
   1. Base Coat Coating Thickness: Thermosetting epoxy powder coating with minimum thickness of 2 to 4 mils (0.0508 to 0.1016 mm).
   2. Top Coat Coating Thickness: No-mar TGIC polyester powder finish with minimum thickness of 2 to 4 mils (0.0508 to 0.1016 mm).
   3. Coating Performance Requirements: coating meets or exceeds the following
      a. Adhesion (ASTM D 3359, Method B): Adhesion over 90 percent of test area (tape and knife test).
      b. Corrosion Resistance (ASTM B 117, ASTM D 1654): Coated galvanized steel shall be capable of salt spray resistance for 3,500 hours without loss of adhesion on parts scribed per ASTM D 1654 and tested in accordance with ASTM Test Method B117. Failure is considered to have occurred when there is either 1/8 inch (3.18 mm) coating loss from the scribed mark or an accumulation of medium #8 blisters.
      c. Impact Resistance (ASTM D 2794): 60 inch pounds, minimum (impaxt using 0.625 inch ball).
      d. Weathering Resistance (ASTM D 822, D 2244, D523 – 60 percent loss of gloss or color variance of more than 3 delta-e color units).
      e. Color: As selected by the Architect.
      f. The stratification-coated framework shall be capable of meeting the performance requirements for each quality characteristic shown in Table 2.

2.4 FABRICATION

A. Pickets, rails and posts shall be pre-cut to specified lengths. Rails shall be pre-punched to accept pickets.

B. The rail inner slide shall be fully inserted into the rail outer channel to form the raceway for the internal retaining rod. Grommets shall be inserted into the pre-punched holes in the rails, and pickets shall be inserted through the grommets so that pre-drilled picket holes align with the internal raceway of the two-part rails. Retaining rods shall be inserted into each rail so that they pass through the pre-drilled holes in each picket, thus completing the panel assembly.

C. Completed panels shall be capable of supporting a 300 lb. load (applied at midspan) without permanent deformation. Panels shall be biasable to a 25% change in grade.

D. Gates shall be fabricated using 1.75” sq. reinforced rail material matching fence panels, 2” sq. x .250” gate ends and 1” sq. x .125” pickets. All rail and upright intersections shall be joined by welding. All picket and rail intersections shall be joined by welding.

2.5 EXECUTION

A. All new installation shall be laid out by the contractor in accordance with the construction plans.

B. All installation requirements to be coordinated by Contractor with PreCast Concrete requirements.

2.6 EXAMINATION

A. Do not begin installation until substrate has been properly prepared.

B. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

2.7 PREPARATION

A. Clean surfaces thoroughly prior to installation.

B. Prepare the grade and remove surface irregularities, if any, which may cause interference with the installation of fencing.

C. If preparation and condition is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

2.8 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Fence posts shall be set in accordance with the manufacturer-recommended spacing. Fence installer shall assist General Contractor in coordinating post spacing with final pre-cast concrete wall layout.

C. Fence posts installed at pre-cast concrete walls shall be anchored to walls by solid-grouted engagement in precast sockets. Grouting material shall be Quik-Rok® chemically engineered hydraulic cement or other manufacturer-approved setting material formulated to provide rigid structural support with no spalling of the pre-cast wall panels.

D. Grouting material shall be shaped (crowned) to facilitate water "run-off", thus eliminating the possibility of freeze-thaw damage. Install grout to prevent sleeve from acting as a water reservoir. Trowel a mound-like head to insure water drain-off.

E. Fence panels shall be attached to posts with brackets supplied by the manufacturer.

F. Posts shall be set in concrete footers shall have a minimum depth of 36" The "Earthwork" and "Concrete" sections of this specification shall govern material requirements for the concrete footer.

G. Impasse panels shall be attached to posts using mounting brackets and tamperproof security fasteners supplied by the manufacturer.

H. When cutting rails immediately seal the exposed surfaces by:
   1. Removing all metal shavings from cut area.
   2. Apply manufacturer-approved primer to thoroughly cover cut edge and drilled hole; allow to dry.

3. Apply 2 coats of manufacturer-approved paint matching fence color.

I. Gate posts shall be spaced according to the manufacturer's gate drawings, dependent on standard out-to out gate leaf dimensions and gate hardware selected.
   1. Type and quantity of gate hinges shall be based on the application; weight, height, and number of gate cycles
   2. The manufacture's gate drawings shall identify the necessary gate hardware required for the application.
   3. Gate hardware shall be provided by the manufacturer of the gate and shall be installed per manufacturer's recommendations.

2.9 ERECTION TOLERANCES

A. Maximum Variation From Plumb: ¼ inch.

B. Maximum Offset From Indicated Position: 1/2 inch

C. Minimum distance from property line: 6 inches.

2.10 COORDINATION

A. Coordinate the Work with Pre-cast Concrete Site Walls, Fire Alarm Systems, Access Controls, and Security Systems.

B. Card Reader Access system by Owner as delineated on Drawings. Hardware to be installed at gate(s). Gate operator to be provided by Contractor.

2.11 CLEANING

A. Leave immediate work area neat at end of each work day.

B. Clean jobsite of excess materials; scatter excess material from post hole excavations uniformly away from posts.

C. Clean fence with mild household detergent and clean water rinse well. Mortar should be removed from exposed posts and other fencing material using a 10% solution of muriatic acid followed immediately by several rinses with clean water.

D. Touch up scratched surfaces using materials recommended by manufacturer. Match touchup paint color to fence finish.

2.12 PROTECTION

A. Protect installed products until completion of project.

B. Touch-up, repair or replace damaged products before Substantial Completion.

END OF SECTION

SECTION 32 31 40

GATE OPERATOR

GENERAL

1.1 SUBMITTALS

A. Product Data: Submit manufacturer's specifications, design data, and installation instructions.

B. Shop Drawings: Submit drawings showing layout, dimensions, and construction details, including wiring diagram.

C. Contract Closeout Submittals: Submit the following in accordance with Section 01 77 00.
1. Operating and Maintenance: Manual for care and operation

1.2 DELIVERY, STORAGE AND HANDLING

A. Packing and Shipping: Deliver materials to site in manufacturer's original unopened packaging with labels intact. Protect finished surfaces with removable wrapping or coating which will not bond when exposed to sunlight.

B. Storage: Adequately protect against damage while stored at the site.

C. Handling: Comply with manufacturer's instructions.

1.3 WARRANTY

A. Provide manufacturer’s standard 5-year limited warranty against all defects in materials or workmanship and 1-year warranty for batteries.
1. Defective materials shall be replaced with comparable materials furnished by the manufacturer, at no cost to the owner. Freight, labor and other incidental costs are not covered under the factory warranty.

PRODUCTS

1.4 MANUFACTURERS.

A. Furnish products of one of the following manufacturers, except as approved by the Architect, subject to compliance with specifications requirements:
1. Chamberlaine www.chamberlain.com
2. Customline www.customlineinc.net
3. Door King www.doorking.com
4. Ameristar Fence Products, Inc., in Tulsa, OK.

1.5 ROLLING GATE OPERATOR

A. Operator
1. Motor: 1/2 hp, 115V or 230V as appropriate for available power (coordinate with Division 26 – Electrical and gate submittal package from contractor), single phase, high starting torque, heavy duty reversible motor, protected against overload and under voltages and separate from the reduction mechanism for easy maintenance. Wire motor so that protection against overload and under voltages will protect both start windings and run windings.
2. Control Circuitry: Starter shall meet NEMA size "0" requirements with mechanical interlock and rated at 660 VAC 25 amps. Control circuitry shall be completely pre-wired to terminal block for field installation. Reduction: Single belt, chain and sprocket moto speed
3. Reduction. Gears, sprockets, pulleys, and chains shall be heavy duty with ratio as recommended by manufacturer. Bearings shall be permanently lubricated.
4. Clutch: Provide heavy duty, adjustable friction type. Clutch shall be designed for safety, to slip if gate meets an obstruction.
5. Limit Switch: Rotary-type driven limit shall be provided to limit travel in the full open and full close position. Switch shall be accurate and fully adjustable without the use of tool, and securely locked in place after adjustment. Switch contacts shall be rated at 10 amp at 120 VAC.
6. Brake: Provide solenoid activated, disc-type, readily adjustable locking brake.
7. Drive Chain: Roller drive chain.
8. Housing: 16 gauge, painted, galvanized steel housing to completely protect the operating mechanism. Housing shall be weather-resistant and have provisions for padlocking.
9. Gate Speed: Travel speed shall be 57 ft. per minute.
10. Reversing Delay: Reversal of gate shall be delayed for 1.5 seconds when signaled from any opening or safety device to reduce shock load on operator.
11. Transformer: 35 VA rated with 24 VAC secondary. Control devices shall be wired to 24V circuit. Controls relays shall have silver cadmium oxide contacts rated are 10 amp to 120 VAC.
12. Power Switch: Provide on/off switch so that power can be disconnected at operator without opening control box. Power switch shall be protected by the weather-resistant housing. Verify type of controls with Owner’s requirements

VERIFY TYPE OF CONTROLS WITH OWNER REQUIREMENTS

B. Digital Keyless Entry Controller:
1. Programmable telephone like pushbutton control station with 10,000 possible codes in weatherproof, hooded design box.
2. Provide with standard bent steel tube pipe support with base plate for surface mounting.
3. Coordinate and tie system to Owner’s security system as directed by Owner.

C. Magnetic Vehicle Detector:
1. Self-tuning sensor system for magnetically reading presence of approaching vehicle.
2. Provide in weatherproof enclosure for exterior mounting.
3. Provide loop detectors and all required PVC conduit.

EXECUTION

1.6 EXAMINATION

A. A. Verification of Conditions: Examine subsurfaces to receive Work and report detrimental conditions in writing to Architect. Commencement of Work will be construed as acceptance of subsurfaces.

B. Coordination: Coordinate with other work which affects, connects with, or will be concealed by this Work.

1.7 INSTALLATION

A. Gate operators and controllers: Install units at locations indicated in accordance with manufacturer's written instructions and approved Shop Drawings.
   1. Provide controller equipped with Fire Department Override Access.
   2. Provide transmitter units to Owner with instructions regarding usage.
   3. Test and adjust operators and controllers for smooth, trouble-free operation.

B. Adjust gate limit switch, clutch and brake, and test for proper operation.

END OF SECTION