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- NOT APPLICABLE

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SECTION 011000 – SUMMARY OF WORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 PROJECT INFORMATION

A. The Rio Hondo College Administration and Data facilities will involve HVAC equipment and electrical repair, replacement and modification of existing systems as follows:

1. Emergency Generator

   Administration facility will have its current power generator unit replaced.

   The room with the existing generator shall be fully demolished and will become the emergency power distribution room.

   The new generator, GDA-1, will be placed outside for safety reasons and will be placed in parking lot F. It will take two existing parking stalls to provide ample service access to the generator and to safeguard it from vehicular traffic.

   The new generator feeders shall be routed up the slope as shown on plans in encased concrete cast in place over 95% compacted soil.

   Above the concrete casement, the fill to sub-furnished service shall be fully filled with two-sack slurry cement with red pigmentation.

   Such pigmentation shall be mixed with the slurry throughout and shall be fully visible.

   The generator, GDA-1, shall be placed above a three point precast vault with service access and a 10 foot gravel drywall to collect any storm water that may accumulate within the vault.

   Vault shall be leveled with surface. Housekeeping pad shall extend to curb and available parking area stall and adjacent curb.

   Four removable and lockable 48-inch aboveground bollards shall be installed in each extremity of the generator housekeeping pad.
The new generator, GDA-1, will connect to the revised emergency power distribution room via an aboveground pull box exterior of the building connecting to the encased concrete termination at the building and providing a 4 foot diameter radius to large conduits.

The pull box shall be rated as NEMA 3R with hinged door, two padlock locations, and an open-handle. It must be marked with a laminated riveted affixed sign “For Authorized Personnel Access Only:” in 4 by 12 inch.

The emergency power distribution from the following requirements shall be included:

a. Three auto-transfer switches.
b. One 75 kVA transformer 480/277 V-ac to 120/208 V-ac.
c. Four future emergency local subpanels.
d. One fused disconnect for providing the AHU-1 fan (please refer to partial electrical single level diagram on sheet E002).
e. Generator exercise and signal conduits with pilot lights, alarm, and 3-inch chart recorder.
f. Three 120 V-ac 15 A circuits with a remote annunciator shall be rooted to the generator.
g. The only initial loads connected to the emergency power generator loads shall be:

1) 120 V-ac to the generator, GDA-1
2) Generator control signal cabling
3) Generator power to ATS-1EHL/1ELL, -1ELP/1NHL, -AHU-1 and power to the transformer, the two 480/277 V-ac subpanels from ATS-1EHL/1ELL, (1) 120/208 V-ac panel and (1) 480/277 V-ac panel attached to ATS-1ELP/1NHL, and the fused disconnect to AHU-1 from ATS-AHU-1.
4) ATS normal power shall connect to existing distribution board DR1 in separate circuits.

2. Data Center

All HVAC and CRAC units at Data Center adjacent offices will be fully replaced.

All existing ceiling duct work and grilles shall be entirely removed.

All walls shall be patched and filled with finishes equal to existing.

The Data Center raised floor shall receive two 5 ton Liebert AC units, CAC-1 and CAC-2, replacing existing CRAC units. The companion Liebert condensing units, CCU-1 and CCU-2, shall be mounted at the same elevation, utilizing existing equipment framing in the loading dock. See sheet M101 for further details.

Locations are adjusted for new operation.
The raised floor in the data room shall be thoroughly cleaned with a professional HEPA vacuum cleaner before and after construction.

New perforated floor tiles shall be installed to match existing. See plans.

New non-perforated tiles shall be placed in areas that required solid tiles to match existing.

The Liebert condensing units, CCU-1 and CCU-2, shall be mounted at the loading dock at the location of the existing heat pump.

The office cooling and heating to Data Center vicinity offices shall be provided by a Trane Variable Refrigerant Flow System (VRF), utilizing both ceiling recessed and wall mounted cassettes (CC and TC) with outside air ducts directly connected to cassettes. See new OA Fan, SF-1, with ECM connected to building automation.

Each indoor TC and WC shall be controlled by a MFR wireless remote to control individual fan speeds and zone temperatures. Velcro shall be adhered to both the wireless remote and the same room wall or desk for convenient storage.

Each CO2 sensor shall pass through a low signal select to adjust the fan speed to achieve 700 PPM (FA) at every zone. CPA internal via virtual point shall be initially set at 700 PPM and controlled by an automatically tuned PI algorithm.

The VRF unit shall be located outside in a location adjacent to the existing power generator. Two new 4-inch rigid metallic conduit for routing of refrigerant lines and power to VCU-1 shall be installed. See sheet M101 for further details.

Coring of concrete sidewall shall be required for outside air ventilation and VRF unit conduit and pipe routing. Please ascertain that coring does not cut through any rebar or internal metal tendons in concrete work. This process may require X-Ray through concrete.

Refer to all Electrical and Mechanical Contract Documents for full project scope.

1.3 COORDINATION AND WORK SITE MAINTENANCE

A. Maintenance of barricades shall require permanent (2) person supervision to redirect vehicular and pedestrian traffic.

B. Coordinate installation of at least (3) 480 V-ac 400 A generators for temporary power. Coordinate with Campus for staging of temporary power with at least (2) weeks notice for staging requirements.
C. All demolished items shall become of status of District’s first right of refusal. District shall not be responsible for the demolition of items. Any demolished items that District chooses to retain as their property shall be delivered to District in palletized form, secured by multiple 1-inch tension straps and wrapped with impermeable visqueen of thickness of no less than (3) mils.

D. Coordinate staging of all new and demolished equipment with Campus, providing Campus with at least (2) weeks notice for staging requirements.

E. Construction crews must wear security reflective vests and construction PPE including hard hats at all times.

F. Construction crew supervisors and managers shall not utilize Campus restroom facilities under any circumstances.

G. Construction crew supervisors and managers shall not communicate with, interfere with, impede the progress of, or disturb any faculty, students, and Campus officials unless the construction individual has written permission signed by the Director of Facilities to do so.

H. Construction crew supervisors and managers shall not enter any building in the facility except those areas demarked on the Scope of Work within the Administration Building, Data Center, and exterior areas barricaded for construction and staging.

I. The Data Center shall remain operable throughout renovation by means and methods provided by Contractor. At the very least, (1) CRAC unit shall remain operational up and until a second unit is fully operational.

J. The existing MovinCool unit may be utilized to augment Contractor means and methods to maintain Data Center front of IT Racks at 72 deg F at all times.

K. All work areas shall be thoroughly cleaned on a daily basis.

L. Where fire alarm systems are temporarily disabled, Contractor shall provide 24-hour fire watch for the period in which the existing fire alarm system(s) is either fully or partially disabled.

M. Restoration of landscape, hardscape, roadway, and curbs shall meet the latest district standard for such items. Uneven or discontinuous finishes shall not be acceptable. The acceptability criteria and the acceptable quality of such restoration of softscape and hardscape shall be at the discretion of Campus officials.

N. Deviate from any underground utility that may come within a proximity of 2 feet from the new encased conduit routing. Such deviations shall maintain a 4 foot radius minimum of the inner concrete encased diameter.

O. Cranes, lift mechanisms, and possibly helicopters shall only be utilized with a written permit by Campus (4) weeks ahead of utilization of any lift apparatus.
1.4 PROTECT THE WORK FROM VANDALISM

A. During Work Hours. Protect the Work from theft, vandalism, and unauthorized entry. The Contractor shall have the sole responsibility for job site security.

B. During Off-Work Hours. During all hours that Work is not being prosecuted, furnish such watchman’s services as Contractor may consider necessary to safeguard materials and equipment in storage on the Project site, including Work in place and in process of fabrication, against theft, acts of malicious mischief, vandalism, and other losses or damages.

1.5 ALTERATIONS WORK DESCRIPTION

A. Refinishing: Refinish all surface areas of the following, as specified:

1. All cutting and patching areas of the Administration building.
2. All cutting and patching areas of the Data Center.

B. In addition to specified replacement of equipment and fixtures restore existing plumbing, heating, ventilation, air conditioning, electrical, steam and chilled water systems to full operational condition.

1.6 PERMITS, LICENSES AND FEES

A. Permits, Licenses and Fees shall be paid by Contractor.

B. Licenses: Contractor shall obtain and pay all licenses associated with construction activities, such as business licenses, Contractors' licenses and vehicle and equipment licenses. All costs for licenses shall be included in the Contract Amount.

C. Parking Fees: Contractor shall obtain and pay for all parking permits and fees for vehicles parked on the Construction Site.

PART 2 - PRODUCTS

Not applicable to this Section.

PART 3 - EXECUTION

Not applicable to this Section.

END OF SECTION 011000
SECTION 011400 – WORK RESTRICTIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 CONTRACTOR’S USE OF PREMISES AND SITE, GENERAL

A. Contractor’s Use of Premises and Site, General: Refer to Contract General Conditions.

1. Contractor shall at all times perform Work so as to impose no hardship on the Trustees or others engaged in the Trustees’ work, nor cause unreasonable delays or hindrance thereto.
2. Construction activities shall be scheduled to minimize disruption to the Campus and to Campus users.
3. Contractor may not interrupt any Campus utilities without prior written permission from the Trustees.

1.3 USE OF PREMISES

A. Use of Site and Existing Building: Limit use of premises to work in areas indicated. Do not disturb portions of site beyond areas in which the Work is indicated.

1. Limits: Confine constructions operations to Project Area defined in Plans, as approved by the Campus Representative. Use of other areas shall be only with the approval of Campus Representative.
2. Campus Occupancy: Where existing buildings and site areas are indicated for continued use by Campus, make provisions to continued use by scheduling and sequencing of Work under the Contract. Make provisions for temporary barriers, enclosures, covers, directional signage and other construction facilities and temporary controls to enable continuing use. Allow also for Campus occupancy of site.

1.4 CONTRACTOR’S USE OF PROJECT AREA

A. Location of Work: The Work shall be accomplished within areas indicated on Drawings as Project Area or, if not indicated, to areas as directed by Campus Representative. Use of other areas, including parking areas, shall be subject to approval by Campus Representative.
1. Contractor shall not unreasonably encumber the site with materials or equipment.
2. Contractor shall assume full responsibility for protection and safekeeping of products stored on the premises.
3. Contractor shall move any stored products which interfere with operations of Campus or contractors performing work under separate contracts for Campus.
4. Temporary closures or restrictions of use of public thoroughfares, necessary to accomplish the Work, shall be made only as approved in advance by public safety and parking authorities having jurisdiction, as directed in writing by the Campus Representative.

B. Contractor's Use of the Project Area: Unless otherwise specified or indicated on the Drawings, during the construction period the Contractor shall have full use of the designated Project Area for construction operations, including use of the site. Contractor's use of Project Area shall be limited only by Campus' right to perform construction operations with its own forces or to employ separate contractors on portions of the Project in accordance with the Contract General Conditions.

C. Continued Use of Existing Building: Maintain existing building in a weather tight condition throughout construction period. Repair damage caused by construction operations. Protect building and its occupants during construction period.

D. Protection of Existing Improvements and Facilities: Contractor shall protect property adjacent to the Project Area and all existing improvements and facilities within the Project Area, including paving and landscaping indicated to remain.

1. All existing improvements and facilities, except those specifically indicated for removal or reconstruction shall be protected with temporary barriers, enclosures and passageways.
2. After completion of Work, existing improvements and facilities shall be restored to original condition and location. Project Area shall be cleaned and restored to presentable condition, equivalent to or better than the condition prior to start of Work.
3. Should existing improvements and facilities be damaged or soiled beyond renovation or repair, new products shall be provided by Contractor equivalent to existing products, as directed by Campus Representative.

E. Project Area Access: Limit access to site to indicated routes and access points as indicated. If routes and access points are not indicated, access shall be as approved and as directed by Campus Representative. Do not restrict access to adjacent facilities and do not restrict access for those performing work under separate contracts for Campus.

1. Access to and egress from Project Area shall be in strict conformance to prearranged routes approved by Campus Representative, with the understanding that curtailment of construction traffic or revision of access routes may be required on short notice if Campus' operations mandate
such changes because of excessive noise or problems of safety, service or supply.

2. Driveways and Entrances: Keep driveways and entrances serving premises clear and available to service and emergency vehicles at all times. Do not use these areas for parking or storage of materials.
   a. Schedule deliveries to minimize use of driveways and entrances.
   b. Schedule deliveries to minimize space and time requirements for storage of materials and equipment on-site.

F. Emergency Access: Provide pathways, drives, gates, directional signage and other provisions as required by authorities having jurisdiction for emergency access to Project Area and adjoining campus facilities.

G. Emergency Egress: Maintain all pathways, drives, gates, and other means of egress during construction as required by public safety authorities having jurisdiction.

1.5 TIME RESTRICTIONS

A. Contractor's Work Hours: Work shall be limited to Monday through Friday, during hours of 6:00 AM to 5:00 PM.
   1. Work on other days and at other hours shall be only with written approval of Campus Representative.
   2. Work during final exam periods at ends of class sessions shall be restricted to minimize noise, vibrations and other distracting and inhibiting activities.
   3. If it becomes necessary to perform Work on weekends and holidays, in order to meet milestone and final completion dates, Work shall be performed at no change in Contract Amount unless authorized by written Change Order or Field Instruction.

B. Utility Outages and Shutdown: Schedule utility outages and shutdowns to nights, weekends, school holidays or times and dates acceptable to and approved by Campus Representative. Limit shutdown of utility services during normal business hours to 2 hours at a time.
   1. Time and duration of outages and shutdowns shall not hinder normal campus activities except as authorized in writing by Campus Representative.
   2. Provide fourteen (14) calendar days notice in writing to Campus Representative of all utility outages and shutdowns. Describe Work to be performed, which utilities will be interrupted and time and duration of interruption.
   3. Contractor shall provide temporary utilities to occupied facilities and adjacent properties when utilities must be interrupted for more than two hours, unless otherwise directed by Campus Representative.
   4. Power interruptions beyond the authorized time shall be subject to liquidated damages in the amount of $5,000 per day.
1.6 NOISE AND VIBRATION RESTRICTIONS

A. Noise Restrictions: Minimize noise from construction activities. Limit loud construction activities to times when classes are not in session in adjacent facilities.

B. Vibration Restrictions: Do not perform activities that cause vibrations in adjacent occupied spaces, including spaces above and below location where Work is performed. If vibrations transmit through structure, perform Work at times when Campus activities are not being conducted.

C. Soil Drilling and Pile Driving: Soils drilling and pile driving shall be conducted only during time periods approved by the Campus Representative. Provide fourteen (14) calendar days notice in writing to Campus Representative prior to commencing with drilling or pile driving.

D. Blasting: Blasting or other use of explosives is not permitted.

1.7 CAMPUS' USE OF SITE AND PREMISES

A. Campus’ Use of Site and Premises: Campus reserves the right to occupy and to place and install equipment in completed or partially completed areas of buildings and site. Such placing of equipment and partial occupancy shall not constitute acceptance of the total Work.

1. Full Campus Occupancy: Campus will occupy site and existing building during entire construction period defined in the Phasing Schedule. Cooperate with Campus during construction operations to minimize conflicts and facilitate Campus usage. Perform the Work so as not to interfere with Campus' operations.

2. Partial Campus Occupancy: Campus reserves the right to occupy and to place and install equipment in completed areas of building provided such occupancy does not interfere with completion of the Work. Such placement of equipment and partial occupancy shall not constitute acceptance of the total Work.

3. Before partial Campus occupancy, mechanical and electrical systems shall be fully operational, and required tests and inspections shall be successfully completed. Unless otherwise agreed, Campus will provide operation and maintenance of mechanical and electrical systems in portions of the building used by Campus. Unless otherwise agreed in writing by the Campus, warrantee periods shall not begin until date established by Notice of Completion filed at Contract closeout.

4. Upon occupancy, Campus will assume responsibility for maintenance and custodial service for occupied portions of building.
PART 2 - PRODUCTS

Not applicable to this Section.

PART 3 - EXECUTION

Not applicable to this Section.

END OF SECTION 01140
SECTION 013100 - COORDINATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SECTION INCLUDES

A. Coordination of Work under Contract.

1.3 RELATED SECTIONS

A. Section 01100 “Summary of the Work”: Various types of Work to be coordinated, including Owner- Furnished/Contractor-Installed products and work under separate Contracts.

1.4 COORDINATION

A. Coordination, General:

1. Coordinate the Work according to provisions stated in Contract General Conditions. Do not delegate responsibility for coordination to any subcontractor.
   a. Anticipate the interrelationship of all subcontractors and their relationship with the total work.
   b. Resolve differences or disputes between subcontractors and materials suppliers concerning coordination, interference, or extent of work between sections. The Contractor's decisions, if consistent with the Contract Documents, shall be final. The Engineer is not required to coordinate work between sections and will not do so.
   c. Coordinate the work of subcontractors and material suppliers, so that their work is performed in a manner to minimize interference with, and to facilitate the progress of the work.

2. Coordinate utility and building services shut-downs and closures of vehicular and pedestrian thoroughfares, including access to buildings and parking areas, to minimize disruption of Campus activities.
3. Be responsible for providing anchorage, blocking, joining and other detailing as required to provide complete project.
4. Do not obstruct spaces required by Code in front of electrical equipment, access doors, etc.

5. Do not cover any piping, wiring, ducts, etc., until properly inspected and approved.

6. Remove and replace any and all Work under any Section which is not in accordance with the Contract Documents with other materials and Work which is in conformance with the Contract Documents. Repair or replace all other Work damaged by these operations at no increase in contract price.

7. This work shall be coordinated with all associated Work in a manner that will insure that all work will be accomplished as rapidly as the progress of the project will permit and so that no work will be delayed for want of associated work.

B. Relationship of Contract Documents: Drawings, Specifications and other Contract Documents in the Project Manual are intended to be complementary. What is required by one shall be as if required by all. What is shown or required, or may be reasonably inferred to be required, or which is usually and customarily provided for similar work, shall be included in the Work.

C. Discrepancies in Contract Documents: In the event of error, omission, ambiguity or conflict in Drawings or Specifications, Contractor shall bring the matter to attention of the Engineer in a timely manner during the bidding period, for determination and direction by the Engineer in accordance with provisions of the Contract General Conditions.

D. Construction Interfacing and Coordination: Layout, scheduling and sequencing of Work shall be solely the Contractor's responsibility.

1. Contractor shall verify, confirm and coordinate field measurements so that new construction correctly and accurately interfaces with conditions existing prior to construction.

2. Contractor shall bring together the various parts, components, systems and assemblies as required for the correct interfacing and integration of all elements of Work. Contractor shall coordinate Work to correctly and accurately connect abutting, adjoining, overlapping and related elements, including work under separate contracts by Campus, utility agencies and companies.

1.5 COORDINATION OF SUBCONTRACTS AND SEPARATE CONTRACTS

A. Superintendence of Work: Contractor shall appoint a field superintendent and a project manager, who shall directly and full time supervise and coordinate all Work of the Contract.

B. Subcontractors, Trades and Materials Suppliers: Contractor shall require all subcontractors, trades, crafts and suppliers to coordinate their portions of Work with the Contractor's field superintendent to prevent scheduling, sequencing, dimensional and other conflicts and omissions.
C. Coordination with Work Under Separate Contracts: Contractor shall coordinate and schedule Work under the Contract with work being performed for Project under separate contracts by Campus, serving utilities and public agencies. Contractor shall make direct contacts with parties responsible for work of the Project under separate contracts, in order to provide timely notifications and to facilitate information exchanges.

1.6 MECHANICAL AND ELECTRICAL COORDINATION

A. Mechanical and Electrical Coordination: Contractor shall be technically qualified and administratively experienced in field coordination for the type of mechanical and electrical Work required for this Project, for the duration of the Work.

1. Work out all "tight" conditions involving work of various sections in advance before installation. If necessary, and before work proceeds in these areas, prepare supplementary drawings for review showing all work in "tight" areas.

2. Provide supplementary drawings and additional work necessary to overcome "tight" conditions at no increase in contract price.

3. Coordinated layout shop drawings shall be dimensionally accurate and detailed, giving complete dimensions of all locations, elevations, and clearances. Show exact locations of the following:

   a. Ductwork
   b. Piping, including fire protection systems.
   c. Valves and piping specialties, including all air vents and drains.
   d. Dampers
   e. Access doors
   f. Control and electrical panels
   g. Adjustable frequency controllers
   h. Motor control centers and transformers
   i. Disconnect switches
   j. Elevator equipment
   k. Electrical cable trays and main conduits

4. Coordinated layout shop drawings shall show actual Engineering and structural constraints and site conditions.

5. Coordination:

   a. Fully coordinate work between trades with actual Engineering, structural, and site conditions.
   b. Coordinate all adjustments required. Clearly identify by circling these adjustments on the coordinated layout shop drawings.
   c. If Contractor has specific questions regarding coordination of the installation with engineer and campus representative and site conditions and work between trades, submit same with appropriate shop drawings documenting areas in question with Contractor's proposed installation.

6. Submission and review of coordinated layout shop drawings:
a. Prepare reproducible drawings.
b. Submit to each trade for review of space allocated to all trades.
c. Revise drawings to compensate for review by each trade.
d. Review revisions with each trade.
e. Submit to Engineer for review.
f. Review of coordinated layout shop drawings is only for verification that Contractor has performed coordination work as specified herein.

1) Review does not include verification of exact dimensions, clearances, arrangements and/or compliance with codes.

7. Final coordinated layout shop drawings shall show that all trades affected have made reviews and shall be signed by each trade at completion of coordination.

a. General Contractor is to assure that each trade has coordinated work with other trades.
b. Include stamp with labeled space for each trade to sign on each submittal indicating that layout shop drawing has been coordinated.
c. No layout shop drawing will be reviewed without stamped and signed coordination assurance by General Contractor.

8. Coordinated layout shop drawings showing work of all trades are required. Individual trade layout shop drawings will not be accepted.

1.7 SUBMITTALS

A. Coordination Documents: Coordinate shop drawings, diagrams and other specified in various product Sections of the Contract Specifications. Submit coordination drawings and schedules as specified below, prior to submitting shop drawings, product data, and samples.

PART 2 - PRODUCTS

Not applicable to this Section.

PART 3 - EXECUTION

3.1 COORDINATION REQUIRED

A. Coordinate progress schedules, including dates for submittals and for delivery of products.
B. Conduct meetings with suppliers, installers and others concerned with the Work, to establish and maintain coordination of layout, sequencing and completion of various elements of Work.

C. Conduct meetings with installers and others concerned with the Work, to properly integrate various mechanical and electrical systems, to facilitate construction and to provide proper access and work space for maintenance, renovation and improvement of system components. Include participation by representatives of Campus, including maintenance personnel.

D. Assist in resolution of conflicts by providing technical advice, coordination drawings and three dimensional representations of integrated system components, including computer and physical models as necessary.

E. At construction progress meetings, report on progress of Work to be adjusted under coordination requirements and any necessary changes in sequencing and scheduling of Work.

F. Transmit minutes of coordination meetings and reports to Campus Representative, Engineer consultants (as applicable) and to meeting participants.

3.2 COORDINATION DOCUMENTS

A. Coordination Drawings and Models: Contractor shall prepare coordination drawings and three-dimensional models, in computer form and in physical form as necessary, to organize layout and installation of mechanical and electrical products for efficient use of available space, for proper sequence of installation, for integration with building structure, for future maintenance and renovation, and to identify potential conflicts between systems and elements.

B. System Services: Contractor shall identify on coordination drawings and models all plumbing and electrical power and signal services required for each component of each system.

1. Contractor shall certify that characteristics of services and controls are correct for each component.
2. Certification shall be in written form and signed by Contractor and mechanical and electrical coordinator.

C. Maintenance and Disposition of Coordination Documentation: Maintain coordination documents, including models, for duration of the Work, recording all changes. After review of original and revised documents and models by Campus Representative and Engineer, submit documents and models as part of Project record documents.
3.3 COORDINATION OF SUBMITTALS

A. Submittal Reviews by Mechanical and Electrical Coordinator: In addition to specified review actions by Contractor, specified in other sections. Submittals Procedures, all product data, shop drawings and samples shall be reviewed by the mechanical and electrical coordinator for proper coordination of various elements of Work, as described in the preceding Article titled "Coordination Documents."

1. Include products to be provided (furnished and installed) under separate contracts by Campus, to the extent that information is provided in the Contract Documents and supplemental instructions from Campus Representative.
2. Review by Contractor shall be completed prior to submission of product data, shop drawings and samples to Engineer for review.
3. Indicate review actions by Contractor by signed review stamp and other appropriate notations on submittals.
4. Coordinate with other review actions to be taken by Contractor.

B. Field Conditions: Contractor shall verify field dimensions and clearances and relationship to available space and anchoring provisions. Report conflicts in writing to the Engineer and the Campus Representative.

C. Product Characteristics: Contractor shall:

1. Verify compatibility of equipment and other elements requiring plumbing, HVAC and electrical services and signals with services to be provided.
2. Verify motor voltages and control characteristics.
3. Coordinate controls, interlocks, wiring of pneumatic switches, and relays.
4. Coordinate wiring and control diagrams.
5. Review the effect of changes in one element of the Work of other elements of the Work. Identify conflicts and report conflicts in written and graphic form to the Engineer and the Campus Representative.
6. Verify information provided in maintenance and operating instructions and coordinate preparation of maintenance and operation data.

3.4 SYSTEM AND EQUIPMENT START-UP

A. Observations of System and Equipment Activation and Start-Up: Contractor shall observe activation and start-up of systems and equipment, including all Work specified in Divisions 2 through 7 with connections to utilities, building services and controls.

1. Contractor shall verify that utilities, building services and control systems are properly connected, complete and functional within criteria of manufacturer and criteria indicated in the Contract Documents.
2. Contractor shall verify that activated elements are properly anchored and that operating components operate properly according to the component's intended design.
3. Contractor shall verify that activated elements of the Work are in operable condition according to normal operating characteristics required by the manufacturer and the Contract Documents.

4. Should adjustments be necessary to activated elements, Contractor shall advise the Engineer and Campus Representative of necessary actions and shall observe that proper actions are performed to achieve required operating characteristics.

B. Observations of System and Equipment Demonstrations: Contractor shall observe performance demonstrations including equipment demonstrations to Engineer and Campus Representative. Record times and additional information required for operation and maintenance manuals.

C. Documentation of Observations of Activation, Start-Up, Adjustment and Demonstration: Contractor shall keep written record of activation, start-up, operational tests and inspections and necessary adjustments and re-tests and re-inspections.

1. Documentation shall include record of time and date of activation, start-up, operational tests and inspections and shall include measured results of tests and inspections.

2. Documentation shall be submitted to Campus Representative and Engineer.

3.5 INSPECTION AND ACCEPTANCE OF EQUIPMENT

A. Contract Completion Review:

1. Prior to Contract Completion review, Contractor shall verify that each component and system has been properly adjusted, cleaned, lubricated, inspected and tested, and is ready operation and use.

END OF SECTION 013100
SECTION 013120 - PROJECT MEETINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 REQUIREMENTS INCLUDED

A. Preconstruction meeting.
B. Construction progress meetings.
C. Pre-installation conferences.

1.3 PRECONSTRUCTION MEETING

A. Preconstruction Meeting: Campus Representative will administer a preconstruction meeting immediately prior to Contractor mobilization onto the project site.
   1. Representatives of the Trustees, the Contractor, Engineer Consultants, and campus representatives, as appropriate, will attend.
   2. Contractor and major subcontractors, as appropriate, shall attend.
B. Schedule: Schedule preconstruction meeting within five days of construction start date established in the Notice to Proceed.
C. Location: Preconstruction meeting will be held at a location as directed by the Campus Representative.
D. Agenda: Preconstruction meeting shall cover the following topics as a minimum.
   1. Special Project Procedures: Site access restrictions, if any, and requirements to avoid disruption of operations at adjoining facilities. Present Campus' requirements for use of premises.
   2. Designation of Key Personnel: Contractor shall designate key personnel and provide a name and address list that includes the following.
      a. Contractor: Project Manager and Superintendent.
      b. Major subcontractors: Principal/Project Manager and Superintendent.
c. Major materials suppliers: Contact person.

3. Subcontractors List: Distribute and discuss list of subcontractors and suppliers.

4. Coordination: Review requirements for Contractor’s coordination of Work. Review sequence and schedule for work being performed for Campus under separate contracts. Discuss coordination of construction to minimize impacts on continuing Campus operations.

5. Project Communication Procedures: Review requirements and administrative requirements for written and oral communications.

6. Campus and Site Security: Review requirements for Contractor to develop and implement site security.

7. Safety Program: Review requirements for Contractor to develop and implement safety program in compliance with Contract General Conditions.

8. Site Access by Campus Representative and Engineer: Review requirements and administrative procedures Contractor may wish to institute for identification and reporting purposes.


10. Project Layout: Review requirements for laying out of Work, including surveying requirements.

11. Construction Facilities: Designate storage and staging areas, construction office areas and parking areas and review site access requirements.

12. Temporary Utilities: Requirements for establishing and paying for temporary water, power, lighting and other utility services during construction, including metering and allowances.


14. Payment Procedures: Review requirements for preparation and submission of applications for progress payments and for final payment.

15. Change Procedures: Review requirements and administrative procedures for Change Orders, Field Instructions and Contractor’s Requests for Interpretation (RFI).


17. Testing and Inspection: Review tests and inspections to be performed by the following.

   a. Independent testing and inspection agency.
   b. Manufacturers and installers.
   c. Serving utilities and public agencies.
   d. Authorities having jurisdiction.

18. Operation and Maintenance Data: Format and content of operation and maintenance manuals.

19. Instruction of Campus’ Personnel: Review requirements and scheduling of instruction of personnel Training as specified.

21. Project Record Documents: Review requirements and procedures for preparing, reviewing and submitting project record drawings and specifications.

22. Construction Cleaning: Review requirements for progress and final cleaning as specified.


1.4 CONSTRUCTION PROGRESS MEETINGS

A. Construction Progress Meetings: Meetings will be held to review progress and quality of construction. The essence of the discussion of each meeting shall be entered into the written record (minutes) of the meeting by the Engineer or the Campus Representative designee.

B. Schedule: Construction progress meetings shall be periodically scheduled throughout progress of the Work. Frequency shall be as determined necessary for progress of Work. Generally, it is intended that construction progress meetings be held at weekly intervals.

C. Administration: The Campus’ Project Representative shall make physical arrangements for meetings. Contractor shall prepare agenda with copies for participants, preside at meetings, record minutes and distribute copies within two working days to Campus Representative, Engineer, participants and those affected by decisions made at meetings. Each discussion item at construction progress meetings shall be numerically identified and carried through subsequent meeting minutes until resolved.

D. Attendance: Contractor's project manager and jobsite superintendent shall attend each meeting. Contractor's subcontractors and suppliers may attend as appropriate to subject under discussion. Campus Representative will attend each meeting. Engineer's consultants will also attend, as appropriate to agenda topics for each meeting and as provided in Campus-Engineer Agreement.

E. Suggested Agenda for Each Construction Progress Meeting:

1. Meeting Minutes: Review and correct, if necessary, minutes of previous meeting.
   a. Unless published minutes are challenged in writing prior to the next regularly scheduled progress meeting, they will be accepted as properly stating the activities and decisions of the meeting.
   b. Persons challenging published minutes shall reproduce and distribute copies of the challenge to all indicated recipients of the particular set of minutes.
   c. Challenge to minutes shall be settled as priority portions of "old business" at the next regularly scheduled meeting.

2. Progress of the Work: Since last meeting and proposed progress.
   a. Identify potential problems which might impede progress.
b. Develop corrective measures and procedures, including but not necessarily limited to additional manloading to regain planned schedule.

c. Review three-week "look ahead" construction schedule, including identification of conflicts and delays.


4. RFI Status: Review status of Requests for Interpretation (RFI) status.

5. Submittals Status: Review shop drawings, product data and samples submission and review status.


7. Old Business: Active discussion topics carried over from previous meetings.


9. Quality Control: Review maintenance of quality standards and identification of non-conforming Work, including proposed remedial measures to be taken by Contractor.

10. Project Record Documents: Status of project record drawings and specifications.


12. Other items affecting progress and quality of the Work.

F. Meeting Time and Location: As mutually agreed by the Engineer, the Contractor, and the Campus Representative at on-site location.

G. Special Meetings: As necessary, the Engineer, the Contractor, or the Campus Representative may convene special meetings to discuss specific construction issues in detail and to plan specific activities.

1.5 PRE-INSTALLATION CONFERENCES

A. Pre-Installation Conferences: When specified in individual product specification Sections, convene a pre-installation conference prior to commencing Work specified in individual product Sections.

1. Require attendance by representatives of firms whose activities directly affect or are affected by Work specified in the Section.

2. Review conditions of installation, preparation and installation procedures and coordination with related Work and work under separate contracts.

1.6 CONTRACT COMPLETION MEETING

A. Contract Closeout Meeting: As specified.
PART 2 - PRODUCTS

Not applicable to this Section.

PART 3 - EXECUTION

Not applicable to this Section.

END OF SECTION 013120
SECTION 013210 - CONSTRUCTION SCHEDULE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Contractor shall develop a network plan and schedule for the project demonstrating complete fulfillment of all contract requirements and shall keep the network plans up to date in accordance with the requirements of this section. Contractor shall employ the Critical Path Method (CPM) in developing the plan and schedule, and in the planning, coordinating, performing and reporting the work under this contract, including all activities of Subcontractors, equipment vendors, suppliers, and any Campus functions that impact the work. It is explicitly understood that the schedule shall be employed by, and is vital to, the Campus Representative and Project Manager in monitoring the progress of the Work and administering this Contract.

B. The CPM schedule shall be prepared using Primavera Project Planner version 3.1, Primavera SureTrak version 3.0, or newer or equal. Equivalency of a proposed substitute CPM program shall be determined by the Campus Representative at his/her sole discretion upon the application of the Contractor. Regardless of which scheduling software is used it must have a the capability of a definitive “Data Date” that will illustrate impacts to individual activities and the overall project where the activities’ progress is not progressing as originally planned or they have not started as planned. If a later version of either Primavera product is used in the development of the schedule it is the responsibility of the contractor to assure that it is readable in Primavera version 3.1.

C. The principles and definition of CPM in terms used herein shall be as follows:

1. CPM network is a graphic description of the construction plan, showing the sequential steps needed to reach the completion of the Work. It shall depict events and tasks, and their interrelationships, and shall recognize the progress that must be made in one task before subsequent tasks can begin. The CPM network shall be comprehensive and shall include all interdependencies and interactions required to perform the Work of the Project. The only activity in the schedule that will not have a predecessor is the Project Start or Notice to Proceed Milestone. The only activity in the schedule that will not have a successor is the Project Completion Milestone. All other activities in the schedule shall have predecessor and successor logic ties.

1.2 SUBMITTALS AND PROCEDURES.

A. Within ten (10) calendar days following receipt of Notice of Selection as Apparent Low Responsible Bidder prior to the full execution of signed
Agreement, and prior to engaging a scheduling consultant or commencing performance of the work specified in this Section with it's own forces, Contractor shall submit to the Campus Representative:

1. The name and the address of the proposed scheduling consultant.
2. Information sufficient to show that the proposed scheduling consultant or Contractor's own organization has scheduling support staff and computer facilities meeting the requirements herein.
3. A list of prior projects, with Trustees telephone contact numbers for which the proposed scheduling consultant or Contractor's own organization, or staff thereof, has performed services similar to those required for this Contract.
4. The acceptability of the proposed scheduler will be at the sole discretion of the Campus Representative.

B. A “Draft” Initial Contract Schedule shall be submitted no later than the pre-construction kick-off

C. Meeting date followed by the Initial Contract Schedule submittal based upon Campus’ comments.

D. Contractor shall submit preliminary submittal schedule to Campus Representative no later than 10 calendar days following the Notice to Proceed.

E. Submit Initial Contract Schedule within 30 calendar days after Campus’ issuance of the Notice to Proceed to Contractor. Submittal of this schedule is a requirement for approval of the Contractor’s first Application for Payment.

F. Submit Final As-Built Schedule.

G. Monthly updated Initial Contract Schedules (hereinafter referred to as the Monthly Baseline Schedules) and reports; three (3) each, referenced herein shall be submitted concurrently in a single package. It is expected that this submittal shall precede by five (5) days the Contractor’s pay application. It is understood that Monthly updated schedules are a condition precedent to the processing of payment applications. Contractor shall also submit a copy of the computer data disks used to produce hard copy submittals. The electronic file of the schedule shall be readable in Primavera Project Planner version 3.1. A PDF file format is not considered an electronic copy of the schedule submittal.

H. All other required reports referenced herein, typically three (3) each per occurrence.

I. Submit one (1) reproducible and three (3) color plots on “E” size sheets (approximately 34 by 44 inch) of each required schedule and three (3) copies of all required reports. Contractor shall also submit a copy of the computer data disks used to produce hard copy submittals. The computer data disks will contain the schedule computer files in Primavera version 3.1 compatible format. A PDF file Format is not considered an electronic copy of the schedule submittal.
1.3 ACCEPTANCE

A. Campus Representative shall have the right to accept or reject both the proposed scheduling consultant or Contractor's proposed Project Manager, Superintendent and Project Engineer. Contractor shall re-propose qualified alternates at no additional cost to the Trustees within three (3) calendar days thereafter and until such time as Campus Representative’s approval is received. Notice to Proceed will not be issued until the three key contractor’s staff members have been approved.

B. Acceptance of the Contractor's Initial Contract Schedule by the Campus Representative will be a condition precedent to the making of any progress payment for work performed beyond ninety (90) days from receipt of the Notice to Proceed.

C. The required schedules and reports shall be prepared and submitted for review and approval in accordance with the General Conditions, Supplemental General Conditions and this Section.

D. The monthly updating of the Baseline Schedule and reports shall be an integral part and basic element of the estimate upon which progress payments will be made. Submittal, review and approval by Campus Representative of these items shall be a condition precedent to the making of progress payments. If, in the judgment of Campus Representative, Contractor fails or refuses to provide a complete updated Monthly Baseline Schedule or reports, as specified, the Contractor will be deemed to have not provided the required estimate upon which progress payments may be made, and shall not be entitled to such progress payments unless or until it has furnished the aforesaid schedules. If the Contractor fails to comply or is late in compliance with this requirement, and the Trustees finds it to be in their best interest to process the monthly payment, an amount not exceeding $10,000 shall be retained from any monthly progress payment until compliance is effected.

E. Trustees shall deduct the withheld amount from the contract amount if delinquent for each additional month. Continued failure by the Contractor to meet its responsibilities under this specification shall be a basis for termination for cause.

F. In the event the contractor submits a viable, contractually compliant construction schedule which indicates project completion at a date earlier than the contractually provided contract duration, the acceptance of such a schedule will not change the contract time. In such an event, a schedule activity entitled “project float”, of a duration equal to the difference between the proposed construction duration and the contract duration, will be added to the schedule. All project float is a project resource for the contractor and the Trustees, and is not for the exclusive use of either party.
1.4 CONSTRUCTION ANALYSIS

A. Contractor shall use Primavera Project Planner version 3.1, Primavera SureTrak version 3.0, or newer or equal. Contractor shall coordinate with Campus Representative to produce the following minimum information with the Initial Contract Schedule:

1. Activity identification;
2. Activity description;
3. Status date and original/remaining duration;
4. Activity percentage complete;
5. Activity duration;
6. Early start/finish and late start/finish;
7. Total float;
8. The predecessor and successor activities for each individual activity;
9. A comparison between the current update and the baseline schedule;
10. Designation of the planned work day/work week for each activity;
11. A near-critical item list of activities with ten (10) working days or less total float;
12. Scheduled and actual manpower loading for each activity; and
13. Scheduled and actual progress payment for each activity.

B. Should the Contractor develop the schedule in any version of a Primavera product newer than Primavera Project Planner version 3.1 or SureTrak version 3.0 the schedule will be developed utilizing the “Project Level” coding not the “Enterprise” or “Global” Level. It is the Contractor’s sole responsibility to insure that all coding included in the schedule on their computer(s) is transferred and readable by the Campus Representative in the electronic format.

1.5 QUALITY ASSURANCE

A. To assist in the preparation and for the production of the required submittal of the Schedules and Reports outlined in this Section, Contractor shall engage, at his own expense, a CPM consultant having the following qualifications, except that Contractor may perform these services with its own organization if Contractor itself has such qualifications:

1. Have a staff of one (1) or more employees regularly engaged and skilled in the application of computerized CPM scheduling methods on similar or larger size construction projects.
2. Possess or have access to computer programs for preparation and production of schedules and reports.
3. Have computer facilities or access on short notice to computer facilities with the capability of delivering a CPM plot and readout within 48-hours, and;
4. Scheduling Software
   a. Contractor shall utilize a Windows-based computer-software program compatible with Primavera Project Planner version 3.1 or Primavera SureTrak version 3.0, or newer or equal.
b. Use of Scheduling Software other than Primavera Project Planner version 3.1 or Primavera SureTrak version 3.0.

1) If the Contractor requests and receives authorization from the Campus Representative to utilize scheduling software other than that indicated above, the Contractor will still be obligated to provide the schedules to the Campus Representative in Primavera Project Planner version 3.1.

2) Any conversions of schedule files that may be required to accommodate the Primavera Project Planner version 3.1 will be performed by the Contractor at no cost to the Trustees.

3) In the event that there is a difference between the schedule as developed in the software utilized by the Contractor and the schedule as converted to and used by the Primavera products, the schedule that is used in the Primavera product shall have primacy.

1.6 CONTRACT DELIVERABLES

A. Draft Initial Contract Schedule:

1. Submission:

   a. Contractor shall submit a “draft” Initial Contract Schedule to Campus Representative no later than the date of the project preconstruction conference as scheduled by the Campus Representative. The draft Initial Contract Schedule will include all activities that are required or anticipated to be complete within the first 90-calendar days of the project. The draft Initial schedule shall also contain a summarization of the remaining activities formatting the remaining work areas, overall contract duration, milestones, etc. for the remainder of the project. Failure to submit this Draft Initial Contract Schedule by the pre-construction kick-off meeting will result in the assessment of Liquidated Damages in the amount of $100.00 per day until it is submitted.

   b. Any revisions deemed necessary by Campus Representative as a result of its review (14 calendar days) shall be incorporated into the Contractor’s “draft” Initial Contract Schedule and re-submitted to Campus Representative for review within ten (10) calendar days after Contractor's receipt of the “draft” Preliminary Initial Contract Schedule from Campus Representative.

2. Form:

   a. Prepare the “draft” Initial Contract Schedule as a time-scaled CPM network showing continuous flow from left to right. Durations and specific calendar dates shall be clearly and legibly shown for the start and finish of each work activity in sufficient detail to demonstrate preliminary planning for the Work and to represent a practical plan to complete the Work within the Contract Time. The
“draft” Initial Contract Schedule shall also be submitted to the Campus Representative in electronic format.

3. The “draft” Initial Contract Schedule shall include but not be limited to:

a. A legend of scheduled activities.
b. Scheduled work activities that clearly indicate the scope of work to be completed.
c. Major milestones, which are critical to the completion of the work, including but not limited to the following: NTP date; mobilization; coordination review and detailing activities; contractor quality control review activities; substantial completion and contract completion.
d. Major work activity categories to be included in the Initial Contract Schedule.
e. Submittals Section, containing submission, review, procurement and delivery of all project materials. All contractually required submittals shall be incorporated into the schedule.
f. Start up, Testing, Inspections and Commissioning.
g. Punch list formulation (Campus Representative etc.) and correction
h. Contractor closeout documentation and training.
i. Contractor punch list corrective work.
j. Demobilization and project completion.
k. Inclement weather days.
l. A plot of the “draft” Initial Contract Schedule with a clearly highlighted critical path.
m. Calendar designations identifying all holidays and non-working days.

n. This “draft” Initial Contract Schedule shall be formatted to accept manpower, resource and cost loading (i.e., resource dictionaries and cost codes, etc.) when fully developed. The cost loading shall be derived from the initial Schedule of Values submitted by the Contractor. Once an accepted Baseline Schedule has been achieved, the costs reflected therein will be the official Schedule of Values for the project and utilized for payment application.

o. The “draft” Initial Contract Schedule shall contain an activity code structure sufficient to allow future sorting/grouping by responsibility or subcontractor, area/location, CSI division, SOV identification, Milestones and a code entitled “Update” that will identify the schedule submission when specific activities were added to the network (new activities, Change Orders, FI’s, etc.).

p. Should the Contractor develop the schedule in any version of a Primavera product newer than Primavera Project Planner version 3.1 or SureTrak version 3.0 the schedule will be developed utilizing the “Project Level” coding not the “Enterprise” or “Global” Level. It is the Contractor’s sole responsibility to insure that all coding included in the schedule on their computer(s) is transferred and readable by them in the electronic format.
1. Contractor shall submit to Campus Representative for review and approval an Initial Contract Schedule no later than fifteen (15) calendar days after Notice to Proceed, but in such time to allow for review and approval thirty (30) days from the Notice to Proceed. The Initial Contract Schedule shall be a computerized detailed task level CPM diagram in precedence diagramming method (PDM) format. A clear delineation of construction activities shall be shown on the Initial Contract Schedule. This schedule shall be manpower, resource and cost loaded. Failure to submit this Initial Contract Schedule within the time frame indicated herein will result in the assessment of Liquidated Damages in the amount of $100.00 per day until it is submitted.

   a. Contractor and requested subcontractors shall participate in a review of the proposed Initial Contract Schedule by Campus Representative when requested to do so. Any revisions deemed necessary by Campus Representative as a result of this joint review shall be re-submitted within ten (10) days after said meeting.

2. All activities in the Initial Contract Schedule shall have sufficient code structure to enable a sort by activity code, or "rollup" of the activities in the form of a Summary Schedule. The code structure will allow sufficient sorting capabilities to group by: responsibility (by subcontractor), location (building, floor, area, etc.), type (submittal, approval, change, etc), milestones, CSI division, etc.

3. The work activities comprising the Initial Contract Schedule shall be of sufficient detail to ensure adequate planning and execution of the Work and such that the schedules provide an appropriate basis for monitoring and evaluating the progress of the Work. A work activity is defined as a singular task that requires time and resources (manpower, equipment, and/or material) to complete in a continuous operation (excepting submittal activities, review/approval activities, and fabrication and procurement activities). No activity shall be less than one (1) nor more than fifteen (15) days in duration for any on-site operation. All holidays and non-working days shall be identified by way of calendar designations.

4. The Initial Contract Schedule shall be a cost, manpower and resource-loaded CPM schedule. Mobilization, bond and insurance costs may be shown separately; however, other general requirement costs, overhead, profit, etc., shall be prorated throughout all the activities. The cost-loaded activities of the Initial Contract Schedule shall roll up into cost accounts from the Schedule of Values, which shall be in Construction Specifications Institute (CSI) format and shall be basis for establishing the distribution of costs within the Schedule of Values. Costs relating to each activity shall be distributed evenly over the duration of the activity.

5. Failure by Contractor to include any element of the work required for the performance of this Contract and completion of the Project, including all submittals, shall not excuse Contractor from completing all work required within the time for completion, notwithstanding Campus Representative's acceptance of the Initial Contract Schedule.

6. No more than 20% of the total number of activities shown on the schedule shall be critical or near critical. Near critical is defined as float less than ten (10) days.
7. The schedule shall indicate the sequence and interdependency of all work activities. All activities shall be linked by finish-to-start (FS) relationships only. No other type of relationships shall be permitted (including, but not limited to: start-to-start, finish-to-finish, and start-to-finish relationships) without the prior written permission of the Campus Representative. Constraints in the schedule shall be limited to those called for in the contract. Any requested additional constraints on activities shall be kept to a minimum and subject to the written permission of the Campus Representative. Lags will not be used without the prior written permission of the Trustees. In no case will positive lags be permitted in Finish-to-Start relationships. Milestones shall also be limited to those specifically called for in the contract. Unless otherwise called for in the contract, there shall be only two milestones; one for the Notice to Proceed and one for Project Completion.

8. A combined three (3) week Look-Ahead Schedule with a one (1) week As-Built Schedule for the previous week shall be submitted by Contractor to Campus Representative for review and approval at each progress meeting. The Contractor shall status the schedule on a weekly basis. This Look-Ahead Schedule shall be derived from this weekly statusing. The cumulative status of the Look-Ahead schedules shall be the basis for the Monthly Update submittal. In no event shall the Contractor utilize a separate schedule for generation and maintenance of the Look-Ahead schedules. If the superintendent’s and revised Baseline Schedule schedule’s logic deviate significantly, a reconciliation of the two schedules shall be required. This revision shall follow procedures as outlined.

9. Critical Work activities are defined as Work activities which, if delayed or extended, will delay the scheduled completion date of the Work. All other Work activities are defined as non-critical Work activities and are considered to have float.

10. Float is defined as the time that a non-critical Work activity can be delayed or extended without delaying the scheduled completion of milestones specified in this Section or the scheduled completion date of the Work, or both. Float time is not for the exclusive use or benefit of either Trustees or Contractor. Neither Contractor nor Trustees shall have an exclusive right to the use of float. Document the effect on the updated Contract Schedule whenever float has been used.

11. Delays of any non-critical Work shall not be the basis for an extension of Contract Time until the delays consume the float associated with that non-critical Work activity and cause the Work activity to become critical.

12. Contractor shall not sequester float through strategies including extending activity duration estimates to consume available float, using preferential logic, using extensive or insufficient crew/resource loading, use of float suppression techniques like Zero Total Float constraints, special lead/lag logic restraints or imposed dates. Use of float time disclosed or implied by the use of alternate float suppression techniques shall be shared to the benefit of both Trustees and Contractor.


14. Once approved by Campus Representative, Contractor’s Initial Contract Schedule shall be known as the Baseline Schedule and shall be used by Contractor for executing the Work of the Contract, including planning, organizing and directing the Work, and reporting its progress until
subsequently revised. No unilateral changes shall be made to the Baseline Schedule without the prior approval and consent of the Trustees, excepting only the reporting of Actual Start, Actual Finish, and Activity Progress.

C. Baseline Schedule Updating and Progress Payments:

1. The Baseline Schedule shall be updated on a monthly basis (or at lesser intervals if deemed necessary by Campus Representative without additional cost to Trustees for reasons such as work activities being thirty (30) days or more behind schedule) for the purpose of recording and monitoring the progress of the work. Contractor shall meet with Campus Representative and Campus Project Manager each month to review actual progress made to date, activities started and completed to date, and the percentage of work completed to date on each activity started but not completed. Upon completion of the joint review, Contractor shall prepare the updated Baseline Schedule and submit it to Campus Representative.

2. The updated Baseline Schedule shall incorporate all changes mutually agreed upon by Contractor and Trustees during preceding periodic reviews and all changes resulting from approved Change Orders and Field Orders. Unauthorized, unilateral contractor changes to logic or activities shall not be allowed.

3. Once each month, prior to submission of the payment application, the Contractor shall submit to the Construction Manager a report generated from the approved schedule that reflects the percent of completion by activity. The Contractor and the Construction Manager shall walk the project to verify the percentage of completion of each activity. Once the percent of completion of each activity is agreed upon the Contractor shall incorporate this data into the schedule update and these percentages shall be the basis for development of that month’s payment application. The contractor shall not separate the percentage of completion from the remaining durations in the calculation of the schedule.

4. The schedule calculation setting for the monthly updates shall be “Retained Logic”. The “Progress Override” setting may only be utilized to identify the differential in the calculated finish date due to “Out of Sequence Progress”. Some Out of Sequence Progress will occur on all projects. However, if it becomes excessive it has a detrimental affect on the schedules forecast of completion and the contractor’s near term work plan. It can also develop a situation where there are two different critical paths. Should the differential in the project completion exceed 10 days utilizing the Retained Logic setting vs. the Progress Override setting, the successor logic of the Out of Sequence activities shall be revised to eliminate the differential. In addition, the Retained Logic setting is the setting that will be used for the adjudication of any time extension requests or delay claims.

5. Acceptance of the Updated Baseline Schedule will be a condition precedent to the making of any progress payments for work performed.

6. It is explicitly understood that the updated schedules are vital to the Trustees in managing, monitoring, and administrating the Project. Delays
D. Reports:

1. Monthly schedule updates shall include the following:
   a. Activity Status Report
   b. Proposed Revisions Report
   c. Computer Diskette or CD with Updated Schedule File
   d. Narrative Report, The Monthly Narrative Report shall contain the following information for each monthly update:
      1) Description of overall project status.
      2) Description of problem areas (referenced to pending change orders as appropriate).
      3) Current and anticipated delays not resolved by approved change order, including:
         a) Cause of the delay.
         b) Corrective action and schedule adjustments to correct the delay.
         c) Known or potential impact of the delay on other activities and milestones.
      4) Changes in the construction sequence.
      5) Pending items and status thereof, including but not limited to:
         a) Pending Change Orders.
         b) Time Extension Requests.
         c) Other Issues relating to Contract Time.

   6) Contract Completion Date status:
      a) If ahead of schedule, the number of calendar days ahead.
      b) If behind schedule, the number of calendar days behind.

   7) Other project or scheduling concerns.

2. Submittal of the monthly reports and schedule updates by Contractor are required regardless of the approval status of the Contract Baseline Schedule or any monthly revision to the Baseline Schedule.

3. The Contractor shall not make unilateral revisions to the Monthly Updates. Should the Contractor desire to revise the schedule logic or durations he/she shall first submit the Monthly Update based upon the previous Monthly Update with just actual start dates, actual finish dates, and/or percentages of completion. Any additional changes other than actual status data will not be allowed. Following this updating and submittal task the Contractor can then submit a copy of this update with
his/her proposed changes. This proposed revised update will clearly be identified as a proposed revision in the Title, Number/Version and File Name.

1.7 RESPONSIBILITY FOR COMPLETION

A. Contractor agrees that at the sole judgment of Campus Representative, whenever it becomes apparent from the current monthly updated Contract Baseline Schedule that the contract completion date will not be met, it will take some or all of the following actions, as approved by Campus Representative, at no additional cost to Trustees:

1. Increase construction manpower in such quantities and crafts as will substantially eliminate, in the judgment of Campus Representative, the backlog of work.
2. Increase the number of working hours per shift, shifts per working day, working days per week, or the amount of construction equipment, or any combination of the foregoing, sufficiently to substantially eliminate, in the judgment of Campus Representative, the backlog of work. This paragraph shall not be construed to permit contractor to violate the work hour restrictions specified in the Contract Document.
3. Reschedule activities to achieve maximum practical concurrence of accomplishment of activities.

1.8 ADJUSTMENT OF TIMES FOR COMPLETION

A. In addition to provisions of the General Conditions, the time for completion of the work will be adjusted in accordance with these procedures.

B. Any request for an adjustment of the Contract Time for completion submitted by Contractor for changes or alleged delays shall be accompanied by a complete Time Impact Analysis, (TIA), which shall be submitted for review within seven (7) days after the initial request for time by Contractor. Time extensions will not be granted unless substantiated by the CPM Schedule, and then not until the CPM project float becomes zero. If Contractor fails to submit a TIA within the aforementioned time period, then the Contractor shall be deemed to have agreed that there is no time impact and that Contractor has irrevocably waived its rights to any additional contract time.

C. Each Time Impact Analysis shall provide information justifying the request and stating the extent of the adjustment requested for each specific change or alleged delay. Each Time Impact Analysis shall be in form and content acceptable to Campus Representative, and shall include, but not be limited to, the following:

1. A fragmentary CPM type network (Fragnet) illustrating how Contractor proposed to incorporate the change or alleged delay into the current updated Baseline Schedule; and
2. Identification of all activities in the current updated Baseline Schedule whose logic is proposed to be amended due to the change or alleged delay, all activities that are/will be affected by the proposed change or alleged delay, together with engineering estimates and other appropriate data justifying the proposal.

D. The Time Impact Analysis shall be determined on the basis of the date or dates when the change or changes were issued, or the date or dates when the alleged delay or delays began. The status of the construction project and Time Impact Analysis shall include event time computations for all affected activities including but not limited to work around sequencing, or recovery options to maintain the original Contract completion date.

E. Time Impact Analyses provided in order to demonstrate the time impact upon the overall project and the time for completion shall be accomplished at no additional cost to Trustees.

F. If Campus Representative finds, after review of the Time Impact Analysis, that Contractor is entitled to any extension of time for completion, the time for completion will be adjusted by Change Order issued by Campus Representative, and Contractor shall then revise the Baseline Schedule accordingly.

1.9 FINAL AS-BUILT SCHEDULE

A. As a condition precedent to final acceptance of the Project, submit a final As-Built Construction Schedule and all final reports which accurately reflect the manner in which the Project was constructed and includes actual start and completion dates for all work activities on the Baseline Schedule.

PART 2 - PRODUCTS

Not applicable to this Section.

PART 3 - EXECUTION

Not applicable to this Section.

END OF SECTION 013210
SECTION 013220 - CONSTRUCTION PROGRESS REPORTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Construction Drawings, Technical Specifications, and general provisions of the Contract, including Contract General Conditions and Supplementary General Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SECTION INCLUDES
   A. Construction progress reports.

1.3 RELATED SECTIONS
   A. All contract documents.

1.4 CONSTRUCTION PROGRESS REPORTS
   A. Daily Log: Contractor shall maintain a written daily log at the job site with the following information as a minimum:
      1. Date.
      2. Weather conditions.
      3. Subcontractors and trades performing Work under the Agreement on the Site, and number of workers each and number of hours worked by each worker.
      4. List of visitors to site, giving name, company or agency affiliation and telephone number.
      5. Descriptions of situations and circumstances which could delay normal progress of Work or which could be basis of claim for change in Contract Time or Contract Sum.
      6. Changes to Work and who authorized changes.
      7. Comments, as Contractor determines are appropriate for Project record.
   B. Submission of Logs: Submit one copy of daily logs to Campus Representative and Engineer at weekly intervals, for review at Construction Progress Meetings.

PART 2 - PRODUCTS

Not applicable to this Section.
PART 3 - EXECUTION

Not applicable to this Section.

END OF SECTION 013220
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SECTION INCLUDES

A. Administrative requirements for shop drawings, product data and samples submittals.

B. Administrative requirements for submittals reporting results of tests and inspections, during field Work.

C. Contractor's review of submittals.

D. Engineer's review of submittals.

E. Product data submittals.

F. Shop drawing submittals.

G. Sample submittals.

H. Reports of results of tests and inspections.

1.3 RELATED SECTIONS

A. All contract documents.

1.4 DEFINITIONS

A. Shop Drawings, Product Data and Samples: Instruments prepared and submitted by Contractor, for Contractor's benefit, to communicate to Engineer the Contractor's understanding of the design intent, for review and comment by Engineer on the conformance of the submitted information to the general intent of the design. Shop drawings, product data and samples are not Contract Documents nor means to substitute products or initiate changes to the Contract Documents.
B. Shop Drawings: Drawings, diagrams, schedules and illustrations, with related notes, specially prepared for the Work of the Contract, to illustrate a portion of the Work.

C. Product Data: Standard published information ("catalog cuts") and specially prepared data for the Work of the Contract, including standard illustrations, schedules, brochures, diagrams, performance charts, instructions and other information to illustrate a portion of the Work.

D. Samples: Physical examples that demonstrate the materials, finishes, features, workmanship and other characteristics of a portion of the Work. Accepted samples shall serve as quality basis for evaluating the Work.

E. Other Submittals: Technical data, test reports, calculations, surveys, certifications, special warranties and guarantees, operation and maintenance data, extra stock and other submitted information and products shall also be not be considered to Contract Documents but shall be information from Contractor to Engineer to illustrate a portion of the Work for confirmation of understanding of design intent.

1.5 ADMINISTRATIVE REQUIREMENTS

A. Administrative Requirements for Submittals: Submittals shall be made in accordance with requirements specified.

B. All submittals shall clearly identify any deviation from specified construction items components and equipment contained in the contract documents. Review of submittals shall not supersede or nullify any portion of the contract documents. Contractor shall be responsible for construction and installation related to this project fully compliant with the construction documents and the intend therein.

C. Failure to identify any deviations in any aspect of the submittals including dimensions and material including performance and any other aspect of the construction documents in the submittals shall be fully rectified by the Contractor.

D. Work deemed none compliant with contract documents by the owner representative or Engineer shall be disinstalled and installed in a manner consider compliant.

E. Contractor Coordination of Submittals: Coordinate preparation and processing of submittals with performance of construction activities. Transmit each submittal sufficiently in advance of performance of related construction activities to avoid delay.

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals and related activities that require sequential activity.
a. Coordinate preparation of submittals with Owner-furnished products. Coordinate submittal preparation and processing schedule with Campus Representative for timely provision of Owner-furnished product information that affect Contractor submittals.

2. Coordinate transmittal of different types of submittals for related elements of the Work so processing will not be delayed by the need to review submittals concurrently for coordination.

   a. The Engineer will return without action submittals requiring coordination with other submittals until related submittals are coordinated.

F. Submittals List: Contractor shall prepare and submit a Submittals List for review and approval by Campus Representative and Engineer. Submittals List shall identify all specified submittals to be made and shall serve as checklist for submittals.

   1. Format shall be suitable for Project and shall be subject to acceptance by Campus Representative and the Engineer. Comply with directions by Campus Representative and the Engineer for scope and format of Submittals List.

G. Transmission of Submittals: Package each submittal appropriately for shipping and handling. Transmit all submittals from Contractor to Engineer, unless otherwise directed, using a transmittal form generated from the Electronic Project Management System. Submittals received from sources other than the Contractor will be returned without action. Include all information specified below for identification of submittal and for monitoring of review process.

   1. Engineer will provide example Letter of Transmittal, if requested.
   2. Engineer will forward one copy of submittal to Campus Representative for review if requested.

H. Timing of Submittals: Make submittals sufficiently in advance of construction activities to allow shipping, handling and review by the Engineer and consultants. Allow sufficient review time so that installation will not be delayed as a result of the time required to process submittals, including time for resubmittals.

   1. No extension of Contract Time will be authorized because of failure to transmit submittals to the Engineer sufficiently in advance of the Work to permit processing.

I. Submittals Identification:

   1. Provide a space approximately four-inches by five-inches on the label or beside the title block on Shop Drawings to record the Contractor's review and approval markings and the action taken. Include the following information on the label for processing and recording action taken:
a. Project name and Trustees project number.
b. Submission date.
c. Name and address of Engineer.
d. Name and address of Contractor.
e. Name and address of subcontractor.
f. Name and address of supplier.
g. Name of manufacturer.
h. Number and title of appropriate Specification Section.
i. Drawing number and detail references, as appropriate.

2. Identify each element on submittal by reference to Drawing sheet number, detail, schedule, room number, assembly or equipment number, Specifications article and paragraph, and other pertinent information to clearly correlate submittal with Contract Drawings. On the submittal transmittal form or separate sheet record deviations from Contract Document requirements, including minor variations and limitations. Include Contractor's certification that information submitted complies with requirements of the Contract Document.

3. Identify each submittal by Specification Section number followed by a number indicating sequential submittal for that Section. Resubmittals shall use same number as original submittal, followed by a letter indicating sequential resubmittal.

4. Place a permanent label or title block on each submittal for identification. Indicate the name of the entity that prepared each submittal on the label or title block.

J. Grouping of Submittals: Unless otherwise specifically permitted by the Engineer, make all submittals in groups containing all associated items. The Engineer may reject partial submittals as incomplete or hold them until related submittals are made. Submittals held or rejected for being partial or incomplete shall not serve as a basis for delay or extension of schedule.

K. Unsolicited Submittals: Unsolicited submittals may be returned unreviewed.

L. Record Submittals: When record submittals are specified, submit three copies or sets only. Record submittals will not be reviewed but will be retained for historical and maintenance purposes.

1.6 SUBMITTALS SCHEDULE

A. Submittals Schedule: As specified in Section 013210 “Construction Schedule.”

1.7 CONTRACTOR’S REVIEW OF SUBMITTALS

A. Contractor’s Review of Submittals: Prior to submission to Engineer for review, Contractor shall review each submittal for completeness and conformance to specified requirements. Contractor shall stamp each submittal with a review action stamp and sign each copy of submittal. Submittals without stamp and
signature will not be reviewed and will be returned. Contractor's submittal action stamp shall certify the following actions by Contractor:

1. Field measurements have been determined and verified.
2. Conformance with requirements of Contract Drawings and Specifications is confirmed.
3. Catalog numbers and similar data are correct.
4. Work being performed by various subcontractors and trades is coordinated.
5. Field construction criteria have been verified, including confirmation that information submitted has been coordinated with the work being performed by others for Campus and actual site conditions.
6. All deviations from requirements of Drawings and Specifications have been identified and noted.
7. Coordination with Owner Provided Products has been completed.

B. Changes in Work: Changes in the Work shall not be authorized by submittals review actions. No review action, implicit or explicit, shall be interpreted to authorized changes in the Work. Changes shall only be authorized by separate written direction from the Campus Representative, in accordance with the Contract General Conditions.

1.8 REVIEW OF SUBMITTALS BY CAMPUS' REPRESENTATIVE AND ENGINEER

A. Review of Submittals by Campus Representative and Engineer: Submittals shall be a communication aid between Contractor and Engineer by which interpretation of Contract Documents requirements may be confirmed in advance of construction.

1. Reviews by Campus Representative, Engineer and consultants shall be only for general conformance with the design concept of the Project and general compliance with the information given in the Drawings and Specifications.
2. Except for submittals for record, information or similar purposes, where action and return is required or requested, the Engineer will review each submittal, mark to indicate action taken, and return promptly, which is generally understood to mean within fourteen (14) calendar days of receipt of the submittal by the Engineer.

B. Review Action: Engineer will stamp each submittal with a uniform, self-explanatory action stamp. Stamp will be appropriately marked, as follows, to indicate the action taken:

1. Final Unrestricted Release: Where submittals are marked "No Exceptions," that part of the Work included in the submittal may proceed. The work generally is in compliance with the Contract Documents.
2. Final-But-Restricted Release: When submittals are marked "Exceptions as Noted," that part of the Work included in the submittal may proceed
provided the modifications noted are properly incorporated. Resubmission is not required.

3. Returned for Re-submittal: When submittal is marked "Revise and Resubmit," do not proceed with that part of the Work covered by the submittal, including purchasing, fabrication, delivery, or other activity. Revise or prepare a new submittal in accordance with the notations; resubmit without delay. Repeat if necessary to obtain a different action mark.

   a. Do not permit submittals marked "Revise and Resubmit" to be used at the Project site, or elsewhere where Work is in progress.
   b. Note: Any work performed prior to receiving a fully approved submittal shall be done at the Contractor's risk and shall be subject to being replaced if Contract requirements are not met.

4. Rejected: When submittal is marked "Rejected", the Work covered by the submittal is not complete or does not conform to the contract documents and cannot proceed. Prepare a complete, new submittal without delay for review.

5. Received for Record: When submittal is marked "For Information Only," the submittal has been reviewed only for evidence that all required submittal types have been provided for record, and without further review of their content by the Engineer. That part of the Work covered by the submittal may proceed provided it complies with notations or corrections on the submittal and requirements of the Contract Documents; final acceptance will depend on that compliance.

6. Not Reviewed: When submittal is marked "Not Reviewed," the submittal is not required by the Contract Documents or is not subject to Engineer review, and is returned without review by the Engineer.

C. Contract Requirements:

1. Review actions by Engineer and consultants shall not relieve the Contractor from compliance with requirements of the Contract Drawings and Specifications, applicable codes and regulatory requirements.

2. No review action, implicit or explicit, shall be interpreted to authorize changes in the Work. Changes shall only be authorized by separate written Change Order or Field Instruction, in accordance with the Contract General Conditions.

1.9 PRODUCT DATA SUBMITTALS

A. Product Data: Catalog cuts, photographs, illustrations, standard details, standard schedules, performance charts, material characteristics, color and pattern charts, test data, roughing-in diagrams and templates, standard wiring diagrams and performance curves and listings by Code authorities and nationally-recognized testing and inspection services. Where product data must be specially prepared because standard printed data is not suitable for use, submit according to requirements for shop drawings, specified below.
1. Material Safety Data Sheets (MSDS): Product Material Safety Data Sheets shall not be included in Product Submittals unless specifically required. MSDS of all materials and construction installation materials utilized shall be submitted with respective MSDS hazards data sheets.

B. Modifications to Standard Product Data: Modify manufacturer's standard catalog data to indicate precise conditions of the Project.

1. Provide space for review action stamps and, if required by authorities having jurisdiction, license seal of Engineer's design consultant, if applicable.
2. Mark each copy to show applicable choices and options. Where printed product data includes information on several products, some of which are not required, mark copies to highlight applicable information.
3. Include the following information:
   a. Manufacturer's printed recommendations,
   b. Compliance with recognized trade association standards,
   c. Compliance with recognized testing agency standards,
   d. Application of testing agency labels and seals,
   e. Notation of dimensions verified by field measurement,
   f. Notation of coordination requirements.

4. Do not submit product data until compliance with requirements of the Contract Documents has been confirmed.
5. Proceed with installation only using reviewed copy of product data. Do not permit use of unmarked copies of product data in connection with construction.

C. Copies: Submit 8 copies, minimum, of original catalog pages or xerographic copies only, with applicable data highlighted and cross-referenced to Drawings and Specifications requirements. Wet-process and thermal paper copies will not be acceptable. Electronic PDF files may be acceptable if approved by the Campus representative. Distribution of product data submittals shall be:

1. Engineer: Two copies.
2. Campus Representative (pre-review): One copy.
3. Campus Representative (post-review): One copy.
4. Project Inspector: One copy.
5. Contractor: Three copies.

1.10 SHOP DRAWINGS SUBMITTALS

A. Shop Drawings: Drawings, diagrams, schedules and other graphic depictions to illustrate fabrication and installation of a portion of the Work. Shop Drawings shall include fabrication and installation drawings, setting diagrams, schedules, patterns, templates and similar drawings. Include the following information:

1. Identification of products and materials included
2. Compliance with referenced standards
3. Notation of coordination requirements
4. Dimensions
5. Notation of dimensions established by field measurement.

B. Coordination: Show all field dimensions and relationships to adjacent or critical features of Work.

C. Preparation of Shop Drawings: Prepare and submit newly prepared information, drawn to accurate scale. Highlight, encircle, or otherwise indicate deviations from the Contract Documents. Do not reproduce Contract Documents or copy standard information as the basis of Shop Drawings. Standard information prepared without specific reference to the Project is not considered Shop Drawings.

1. Provide space for review action stamps and, if required by governing authorities having jurisdiction, license seal of Engineer and design consultant, if applicable.
2. Prepare shop drawings on minimum sheet size of 17-inches by 22-inches, or smaller if a multiple of 8-1/2 inches by 11-inches. Maximum size shall be 36-inches by 48-inches.
3. Except as noted in product Specifications Sections, submit seven markable and scan-reproducible black-line or electrostatically plotted prints of shop drawings. One original, marked-up review drawing and one copied print will be returned after review. Hand-written copies of shop drawings may be provided in lieu of facsimile copies at the Engineer’s discretion.
4. Do not use Shop Drawings without an appropriate final review stamp indicating action taken in connection with construction.

D. Distribution of Reviewed Shop Drawings: Distribution of reviewed shop drawings will be by Engineer.

1. Engineer: One copy (from reviewed reproducible).
2. Campus Representative: One copy (pre-review print) and one copy (from reviewed reproducible).
3. Project Inspector: One copy (from reviewed original).
4. Contractor: One copy (reviewed original) and one copy (opaque print).

1.11 MANUFACTURER’S INSTRUCTIONS

A. Manufacturer's Instructions: Submit manufacturer's instructions for preparation, mixing, assembly, handling, application and installation of products, as applicable and as specified in product Sections of the Specifications.

1. Include applicable ICBO ES Evaluation Reports. Evaluation Reports shall be current and shall be annotated for applicable products.
2. Include applicable Material Safety Data Sheets, for Project record only.
3. Include written recommendations, as applicable, from manufacturer for Project conditions.
B. Copies: Submit five copies minimum. Distribution will be:

1. Campus Representative: One copy
2. Engineer: Two copies.
3. Project Inspector: One copy.
4. Contractor: As necessary, retained by Contractor.
5. Reviews by Engineer and Campus’ Representative: Manufacturer’s instructions shall be for information and will not be reviewed by Engineer or Campus Representative.

1.12 REPORTS OF RESULTS OF INSPECTIONS AND TESTS

A. Reports of Results of Inspections and Tests: Submit technical data, test reports, calculations, surveys, and certifications based on field tests and inspections by independent inspection and testing agency and by authorities having jurisdiction.

1. Reports of results of inspections and tests shall not be considered Contract Documents.
2. Quality Control for additional requirements.

1.13 OPERATION AND MAINTENANCE DATA SUBMITTALS

A. Operation and Maintenance Data Submittals: Refer to requirements specified. Include operation and maintenance data submittals in Submittals Schedule.

PART 2 - PRODUCTS

Not applicable to this Section.

PART 3 - EXECUTION

Not applicable to this Section.

END OF SECTION 013300
SECTION 013400 – REQUESTS FOR INTERPRETATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SECTION INCLUDES

A. Procedures for submitting requests for interpretation (RFI).

B. Limitations on use of RFI to obtain interpretation and clarification.

1.3 RELATED SECTIONS

A. All contract documents.

1.4 DEFINITIONS

A. Request for Interpretation: A document submitted by the Contractor requesting clarification of a portion of the Contract Documents, hereinafter referred to as an RFI.

1.5 CONTRACTOR'S REQUESTS FOR INTERPRETATION (RFIs)

A. Contractor’s Requests for Interpretation (RFIs): Should Contractor be unable to determine from the Contract Documents the exact material, process, or system to be installed; or when the elements of construction are required to occupy the same space (interference); or when an item of Work is described differently at more than one place in the Contract Documents; the Contractor shall request that the Engineer make an interpretation of the requirements of the Contract Documents to resolve such matters. Contractor shall comply with procedures specified herein to make Requests for Interpretation (RFIs).

B. Submission of RFIs: RFIs shall be prepared and submitted through the Campus’ Electronic Project Management System in a format approved by the Engineer.

1. Forms shall be completely filled in. Supporting drawings or information shall be fully legible after copying by electronic scanning or xerographic process.

2. Each RFI shall be given a discrete, consecutive number.
3. Each page of the RFI and each attachment to the RFI shall bear the Campus’ project name, project number, date, RFI number and a descriptive title.

4. Contractor shall sign all RFIs attesting to good faith effort to determine from the Contract Documents the information requested for interpretation. Frivolous RFIs and RFIs pertaining to non-compliant work, repairs or other re-work proposals shall be subject to reimbursement from Contractor to Campus for fees charged by Engineer, consultants and other design professionals engaged by the Campus.

C. Subcontractor-Initiated and Supplier-Initiated RFIs: RFIs from subcontractors and material suppliers shall be submitted through, be reviewed by and be attached to an RFI prepared, signed and submitted by Contractor. RFIs submitted directly by subcontractors or material suppliers will be returned unanswered to the Contractor.

1. Contractor shall review all subcontractor- and supplier-initiated RFIs and take actions to resolve issues of coordination, sequencing and layout of the Work.
2. RFIs submitted to request clarification of issues related to means, methods, techniques and sequences of construction or for establishing trade jurisdictions and scopes of subcontracts will be returned without interpretation. Such issues are solely the Contractor's responsibility.
3. Contractor shall be responsible for delays resulting from the necessity to resubmit an RFI due to insufficient or incorrect information presented in the RFI.

D. Requested Information: Contractor shall carefully study the Contract Documents, in particular, Article 5 of the Contract General Conditions, to ensure that information sufficient for interpretation of requirements of the Contract Documents is not included. RFIs that request interpretation of requirements clearly indicated in the Contract Documents will be returned without interpretation.

1. In all cases in which RFIs are issued to request clarification of issues related to means, methods, techniques and sequences of construction, for example, pipe and duct routing, clearances, specific locations of Work shown diagrammatically, apparent interferences and similar items, the Contractor shall furnish all information required for the Engineer or Campus Representative to analyze and/or understand the circumstances causing the RFI and prepare a clarification or direction as to how the Contractor shall proceed.
2. In all cases in which RFIs are issued to repair or re-work a non-compliant or damaged condition, the Contractor shall furnish all information required for the Engineer or Campus Representative to analyze and/or understand the circumstances causing the RFI and a proposed method of repair or re-work for Engineer’s and Campus Representative’s review.
3. If information included with this type RFI by the Contractor is insufficient, the RFI will be returned unanswered.

E. Unacceptable Uses for RFIs: RFIs shall not be used to request the following:
1. Review of submittals
2. Review of substitutions
3. Changes that entail change in Contract Time and Contract Sum (comply with provisions of the Contract General Conditions, as discussed in detail during pre-construction meeting)
5. Frivolous RFIs, including duplicate or redundant requests, information contained within the Contract Documents, incomplete or inaccurate requests, or Contractor's means and methods.

F. Disputed Requirements: In the event the Contractor believes that a clarification by the Campus Representative results in additional cost or time, Contractor shall comply with the Contract General Conditions.

G. RFI Log: Contractor shall prepare and maintain a log of RFIs through the Campus' Electronic Project Management System, and at any time requested by the Campus Representative, the Contractor shall furnish copies of the log showing all outstanding RFIs.

H. Review Time: Engineer will return RFIs to Contractor and Campus Representative within an average of 5 to 10 regular working days of receipt by the Engineer. RFIs received after 12:00 noon shall be considered received on the next regular working day for the purpose of establishing the start of the response period.

PART 2 - PRODUCTS

Not Applicable to this Section.

PART 3 - EXECUTION

Not Applicable to this Section.

END OF SECTION 013400
SECTION 014500 - QUALITY CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Construction Drawings, Technical Specifications, and general provisions of the Contract, including Contract General Conditions and Supplementary General Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SECTION INCLUDES
   A. Regulatory requirements for testing and inspection.
   B. Contractor's quality control.
   C. Quality of the Work.
   D. Inspections and tests by authorities having jurisdiction.
   E. Inspections and tests by serving utilities.
   F. Inspections and tests by manufacturer's representatives.

1.3 RELATED SECTIONS
   A. All contract documents.

1.4 REGULATORY REQUIREMENTS FOR TESTING AND INSPECTION
   A. Building Code Requirements: Comply with requirements for testing and inspections in the California Building Code (CBC), as interpreted by authorities having jurisdiction. Additional requirements for testing and inspection, as adopted by authorities having jurisdiction, shall be included in the Contract Sum and Contract Time.
   B. Requirements of Fire Regulations: Comply with testing and inspection requirements of the Fire Marshal having jurisdiction. All tests and inspections shall be included in Contract Sum and Contract Time.

1.5 CONTRACTOR'S QUALITY CONTROL
   A. Contractor's Quality Control: Contractor shall ensure that products, services, workmanship and site conditions comply with requirements of the Drawings and
Specifications by coordinating, supervising, testing and inspecting the Work and by utilizing only suitably qualified personnel.

B. Quality Requirements: Work shall be accomplished in accordance with quality requirements of the Drawings and Specifications, including, by reference, all Codes, laws, rules, regulations and standards. When no quality basis is prescribed, the quality shall be in accordance with the best accepted practices of the construction industry for the locale of the Project, for projects of this type.

C. Quality Control Personnel: Contractor shall employ and assign knowledgeable and skilled personnel as necessary to perform quality control functions to ensure that the Work is provided as required.

D. Coordination of Field Quality Control: Contractor shall coordinate and schedule field quality control activities of Campus’ independent testing and inspection agency and inspectors from authorities having jurisdiction.

1.6 QUALITY OF THE WORK

A. Quality of Products: Unless otherwise indicated or specified, all products shall be new, free of defects and fit for the intended use.

B. Quality of Installation: All Work shall be produced plumb, level, square and true, or true to indicated angle, and with proper alignment and relationship between the various elements.

C. Protection of Existing and Completed Work: Take all measures necessary to preserve and protect existing and completed Work free from damage, deterioration, soiling and staining, until Acceptance by the Campus.

D. Standards and Code Compliance and Manufacturer's Instructions and Recommendations: Unless more stringent requirements are indicated or specified, comply with manufacturer's instructions and recommendations, reference standards and building code research report requirements in preparing, fabricating, erecting, installing, applying, connecting and finishing Work.

E. Deviations from Standards and Code Compliance and Manufacturer's Instructions and Recommendations: Document and explain all deviations from reference standards and building code research report requirements and manufacturer's product installation instructions and recommendations, including acknowledgement by the manufacturer that such deviations are acceptable and appropriate for the Project.

F. Verification of Quality: Work shall be subject to verification of quality by Campus or Engineer in accordance with provisions of the Contract General Conditions.

1. Contractor shall cooperate by making Work available for inspections and observations by Campus’ Representative, Testing Agencies, Engineer and their consultants.
2. Such verification may include mill, plant, shop, or field inspection, as required.
3. Provide access to all parts of the Work, including plants where materials or equipment are manufactured or fabricated.
4. Provide all information and assistance as necessary, including that from subcontractors, fabricators, materials suppliers and manufacturers, for verification of quality by Campus’ Representative or Engineer.
5. Contract modifications, if any, resulting from such verification activities shall be governed by applicable provisions in the Contract General Conditions.

G. Observations by Engineer and Consultants: Periodic and occasional observations of Work in progress will be made by Engineer and consultants as deemed necessary to review progress of Work and general conformance with the design intent.

H. Limitations on Inspection, Test and Observations: Employment of an independent testing and inspection agency and observations by Engineer and consultants shall not relieve Contractor of the obligation to perform Work in full conformance to all requirements of Contract Documents and applicable Building Code and other regulatory requirements.

I. Rejection of Work: The Campus reserves the right to reject any and all Work not in conformance to the requirements of the Contract Documents.

J. Correction of Non-Conforming Work: Non-conforming Work shall be modified, replaced, repaired or redone by the Contractor at no change in Contract Sum or Contract Time.

K. Acceptance of Non-Conforming Work: Acceptance of non-conforming Work, without specific written acknowledgement and approval of the Campus Representative, shall not relieve the Contractor of the obligation to correct such Work.

L. Contract Adjustment for Non-conforming Work: Should Campus Representative determine that it is not feasible or not in Campus’ interest to require non-conforming Work to be repaired or replaced, an equitable reduction in Contract Sum shall be made by agreement between Campus Representative and Contractor. If an equitable amount cannot be agreed upon, a Field Instruction will be issued and the amount in dispute resolved in accordance with applicable provisions of the Contract General Conditions.

M. Non-Responsibility for Non-Conforming Work: Engineer and consultants disclaim any and all responsibility for Work produced that is not in conformance with the Contract Drawings and Contract Specifications.
1.7 INSPECTIONS AND TESTS BY AUTHORITIES HAVING JURISDICTION

A. Inspections and Tests by Authorities Having Jurisdiction: Contractor shall cause all tests and inspections required by authorities having jurisdiction to be made for Work under this Contract.

1. Except as specifically noted, scheduling, coordinating and conducting such inspections and tests shall be solely the Contractor's responsibility.
2. All time required for inspections and tests by authorities having jurisdiction shall be included in the Contract Time.
3. Costs for inspections and tests by authorities having jurisdiction will be paid by Campus.

1.8 INSPECTIONS AND TESTS BY SERVING UTILITIES

A. Inspections and Tests by Serving Utilities: Contractor shall cause all tests and inspections required by serving utilities to be made for Work under the Contract.

1. Except as specifically noted, scheduling, coordinating and conducting such inspections and tests shall be solely the Contractor's responsibility. All time required for inspections and tests by serving utilities shall be included in the Contract Time.
2. Except as specifically noted, all costs for inspections and tests by serving utilities shall be included in the Contract Sum.

1.9 INSPECTIONS AND TESTS BY MANUFACTURER'S REPRESENTATIVES

A. Inspections and Tests by Manufacturer's Representatives: Contractor shall cause all specified tests and inspections to be conducted by materials or systems manufacturers. Additionally, all tests and inspections required by materials or systems manufacturers as conditions of warranty or certification of Work shall be made, the cost of which shall be included in the Contract Sum.

1. Scheduling, coordinating and conducting such inspections and tests shall be solely the Contractor's responsibility. All time required for inspections and tests by manufacturer's representatives shall be included in the Contract Time.
2. All costs for inspections and tests by manufacturer's representatives shall be included in the Contract Sum.

1.10 INSPECTIONS BY INDEPENDENT TESTING AND INSPECTION AGENCY

A. Inspections by independent Testing Laboratory, code and standard authorized inspection agencies.

PART 2 - PRODUCTS
Not applicable to this Section.

PART 3 - EXECUTION

Not applicable to this Section.

END OF SECTION 014500
SECTION 015100 - TEMPORARY UTILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SECTION INCLUDES

A. Temporary utilities and services, including:
   1. Heating and cooling during construction.
   2. Ventilation during construction.
   3. Temporary water service.
   4. Temporary sanitary facilities.
   5. Temporary power and lighting.
   6. Construction telephone service.

B. Removal of temporary utilities.

1.3 RELATED SECTIONS

A. Section 011000 “Summary of the Work.”

1.4 SUBMITTALS

A. Temporary Utilities: Submit reports of tests, inspections, applicable meter readings and similar procedures performed on temporary utilities.

1.5 TEMPORARY UTILITIES AND SERVICES

A. Temporary Utilities and Services, General: All utilities and other services necessary for proper performance of the Work shall be provided by Contractor, unless specifically noted otherwise. Refer to Contract General Conditions. Temporary utilities and services shall conform to all applicable requirements of authorities having jurisdiction and serving utility companies and agencies, including the following:

   1. Requirements of authorities having jurisdiction, including:
      a. Cal OSHA.
      b. California Building Code (CBC) requirements.
c. Health and safety regulations.

d. Utility agency and company regulations.

e. Police, Fire Department and Rescue Squad rules.

f. Environmental protection regulations.

2. Standards:

   b. ANSI A10 Series - Safety Requirements for Construction and Demolition.
   c. NECA Electrical Design Library - Temporary Electrical Facilities.
   d. Electrical Service: Comply with NEMA, NECA and UL standards and regulations for temporary electric service. Install service in compliance with California Electrical Code (CEC).

B. Inspections: Arrange for authorities having jurisdiction to inspect and test each temporary utility before use. Obtain required certifications and permits.

C. Temporary Connections and Fees: Contractor shall arrange for services and pay all fees and service charges for temporary power, water, sewer, gas and other utility services necessary for the Work.

   1. Contractor shall apply for and obtain permits for temporary utilities, including permits for temporary generators, from authorities having jurisdiction.
   2. All costs for temporary connections, including fees charged by serving utilities, shall be included in Contract Sum.

D. Permanent Connections and Fees: Contractor shall arrange for utility agencies and companies to make permanent connections. Campus will arrange for permanent utility account and pay permanent connection fees. After Contract Completion review and determination that Work is acceptable, Campus will pay utility service charges for services delivered through permanent connections, for normal quantities.

E. Use of Temporary Utilities: Enforce strict discipline in use of temporary utilities to conserve on consumption. Limit use of temporary utilities to essential and intended uses to minimize waste and abuse.

1.6 PROJECT CONDITIONS

A. Conditions of Use: Keep temporary services and facilities clean and neat in appearance. Operate in a safe and efficient manner. Take necessary fire prevention measures. Do not overload facilities, or permit them to interfere with progress. Do not allow hazardous, dangerous, or unsanitary conditions, or public nuisances to develop or persist on the site.
1.7 HEATING AND COOLING

A. Temporary Heating and Cooling: Provide and pay for temporary heating and cooling devices, fuel and related service charges to provide ambient temperatures as required to maintain conditions necessary for proper performance of construction activities.

B. Use of Permanent Heating and Cooling Systems: Permanent heating and cooling equipment may be used after completion, testing and inspection of systems and approval of code authorities having jurisdiction.

1. Prior to operation of permanent heating equipment for temporary heating purposes, verify that installation is approved for operation, equipment is lubricated and filters are in place.
2. Contractor shall provide and pay for operation, maintenance and regular replacement of filters and worn or consumed parts.
3. Immediately prior to Contract Completion review, change disposable filters and clean permanent filters of equipment used during construction.

C. Temperature Criteria: Maintain interior ambient temperature of minimum 50 degrees F and maximum 80 degrees F, unless otherwise specified or approved by Campus Representative.

1.8 VENTILATION DURING CONSTRUCTION

A. Ventilation During Construction: Provide and pay for temporary ventilation devices, energy and related service charges. Design of temporary ventilation systems of spaces maintaining occupancy during construction shall be the responsibility of the Contractor.

1.9 TEMPORARY WATER SERVICE

A. Temporary Water Service: Contractor shall locate and connect to existing water source for temporary construction water service. Contractor shall comply with the following:

1. Locate and connect to existing water source for temporary construction water service, as acceptable to Campus Representative.
2. Extend branch piping with outlets located, so that water is available by use of hoses.
3. Temporary water service piping, valves, fittings and meters shall comply with requirements of the serving water utility and California Plumbing Code (CPC).
4. All costs to establish temporary construction water system shall be included in the Contract Sum, of if so specified, costs shall be paid from Allowance specified.

B. Use of Permanent Water System: Permanent water system may be used for construction water after completion, sterilization, testing and inspection of
system and approval by Campus Representative and authorities having jurisdiction.

1.10 TEMPORARY SANITARY FACILITIES

A. Temporary Sanitary Facilities: Provide and maintain adequate temporary sanitary facilities and enclosures for use by construction personnel.

1. Number of temporary toilets shall be suitable for number of workers.
2. Provide wash-up sink with soap, towels and waste disposal.

B. Use of Permanent Sanitary Facilities: Do not use permanent sanitary facilities unless approved by Campus Representative. Immediately prior to Contract Completion review, thoroughly clean and sanitize permanent sanitary facilities used during construction.

1.11 TEMPORARY POWER AND LIGHTING


B. Temporary Power: Provide electric service as required for construction operations, with branch wiring and distribution boxes located to provide electrical service for performance of the Work.

1. Provide temporary electric feeder connected to electric utility service at location determined by Contractor and as approved by serving electric utility.
2. Temporary power conduit, raceways, fittings, conductors, panels, connections, disconnects, overcurrent protection, outlets and meters shall comply with requirements of the serving electric utility, California Electrical Code (CEC) and requirements of authorities having jurisdiction.
3. Contractor shall pay all costs to establish temporary electric service.
4. As necessary in order to maintain construction progress, Contractor shall provide and pay all costs associated with generators used for temporary power.

C. Temporary Lighting: Provide temporary lighting as necessary for proper performance of construction activities and for inspection of the Work.

1. Provide branch wiring from power source to distribution boxes with lighting conductors, pigtails, and lamps as required.
2. Maintain lighting and provide routine repairs.

D. Protection: Provide weatherproof enclosures for power and lighting components as necessary. Provide overcurrent and ground-fault circuit protection, branch wiring and distribution boxes located to allow convenient and safe service about site of the Work. Provide flexible power cords as required.
E. Use of Permanent Power and Lighting Systems: Permanent power and lighting systems may be used after completion, testing and inspection of systems and approval by Campus Representative and authorities having jurisdiction.

1. Contractor shall maintain lighting and make routine repairs and replacements as necessary.
2. Campus shall not pay for electricity consumed after permanent power system is operational and approved by authorities having jurisdiction. Campus shall not pay for the cost of wasted electricity, for example, lighting beyond hours of construction.

F. Service Disruptions: When necessary for energizing and de-energizing temporary electric power systems, minimize disruption of service to those served by public mains. Schedule transfers at times convenient to Campus and to occupants.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Materials: Contractor shall provide new materials. If acceptable to the Engineer, undamaged previously used materials in serviceable condition may be used. Provide materials that are suitable for the use intended. Their use and methods of installation shall not create unsafe conditions or violate requirements of applicable codes and standards.

B. Equipment: Contractor shall provide new equipment; or, if acceptable to the Trustees, Contractor may provide undamaged, previously used equipment in serviceable condition. Provide equipment that is suitable for use intended.

PART 3 - EXECUTION

3.1 TEMPORARY UTILITIES INSTALLATION

A. Temporary Utilities Installation, General: Contractor shall engage the appropriate local utility company or personnel to install temporary service or connect to existing service.

1. Use Charges: Cost or use charges for temporary facilities are the Contractor's responsibility.
2. Allowance for Utilities Charges: When Contract includes an allowance for metering of utility services, whether through temporary or permanent facilities, unused amount shall be returned to the Trustees by deductive change order.

B. Water Service: Contractor may take water from the Campus' systems in such quantities and at such times as they are available. If this is done, Contractor
shall provide all temporary materials necessary to extending the utility to where they will be used. Contractor shall install a meter and reimburse the Campus for any water used.

C. Temporary Electric Power Service: Contractor may take electricity from the Campus’ system if available. If this is done, Contractor shall provide all equipment, including connections, and other materials necessary for extending the utility lines to where they will be used. Contractor shall coordinate the installation with the Campus Representative. Contractor shall install a meter and reimburse the Campus for any power used. Where sub-metering is not possible or practical, a flat fee may be established and paid to the Campus.

1. When not available from the Campus, the Contractor must arrange and pay for electric service through the local utility or furnish his own portable power.
2. All permanent power used by the Contractor prior to Occupancy by the Trustees shall be metered and paid for by the Contractor.

D. Temporary Fire Protection: Until fire protection needs are supplied by permanent facilities, Contractor shall install and maintain temporary fire protection facilities of the types needed to protect against reasonably predictable and controllable fire losses. Contractor shall comply with NFPA 10 “Standard for Portable Fire Extinguishers,” and NFPA 241 “Standard for Safeguarding Construction, Alterations and Demolition Operations.” Contractor shall:

1. Locate fire extinguishers where convenient and effective for their intended purpose, but not less than one extinguisher on each floor at or near each usable stairwell.
2. Store combustible materials in containers in fire-safe locations.
3. Maintain unobstructed access to fire extinguishers, fire hydrants, temporary fire protection facilities, stairways and other access routes for fighting fires. Prohibit smoking in hazardous fire exposure areas.
4. Provide supervision of welding operations, combustion type temporary heating units, and similar sources of fire ignition.
5. Should existing fire alarm or fire suppression systems be taken off line, provide a continuous fire watch in accordance with local Fire Authority requirements until the system(s) are made functional again.

E. Maintenance of Temporary Utilities and Services: Contractor shall maintain temporary utilities and services in good operating condition until removal. Contractor shall protect from utilities and services from environmental and physical damage.

3.2 TERMINATION AND REMOVAL OF TEMPORARY UTILITIES AND SERVICES

A. Termination and Removal of Temporary Utilities and Services: Unless the Trustees require that it be maintained longer, Contractor shall remove each temporary facility when the need has ended, or when replaced by authorized
use of a permanent facility, or no later than Completion. Contractor shall complete or, if necessary, restore permanent construction that may have been delayed because of interference with the temporary facility. At Completion, Contractor shall clean and renovate permanent facilities that have been used during the construction period.

B. Removal of Temporary Underground Utilities and Restoration: Remove temporary underground utility installations to a minimum depth of two-feet below utility services. Contractor shall:

1. Backfill, compact and regrade site as necessary to restore areas or to prepare for indicated paving and landscaping. All subterranean items such as precast vaults, house keeping pads, concrete encased conduits shall be installed above 95% compacted trench soil.
2. Utilize a two-slack slurry cement with red pigmentation above concrete encased conduits and other components up to location of restoration of hardscape including asphalt, sidewalk, curbs and other existing surfaces to match campus standard.
3. Utilize a two-slack slurry cement with red pigmentation above concrete encased conduits and other components up to location of restoration of landscape according to campus standard.
4. Restore paving damaged by temporary utilities.

C. Cleaning and Repairs: Contractor shall clean exposed surfaces and repair damage caused by installation and use of temporary utilities and services. Where determined by Campus Representative that repair of damage is unsatisfactory Work, Contractor shall replace construction with matching finishes.

END OF SECTION 015100
PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Construction Drawings, Technical Specifications, and general provisions of the Contract, including Contract General Conditions and Supplementary General Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SECTION INCLUDES
   A. Contractor Staging Area requirements.

1.3 RELATED SECTIONS
   A. All contract documents.

1.4 SUBMITTALS
   A. Shop Drawings: Prior to site mobilization, Contractor shall prepare and submit for review by Campus Representative a site plan indicating detailed layout of Contractor Staging Area, including:
      1. Temporary utilities.
      2. Temporary fencing and gates.
      3. Temporary offices and sheds.
      5. Vehicular accessways and on-site parking.
      6. Temporary barriers and enclosures.
      7. Storm water pollution prevention measures.

PART 2 - PRODUCTS
Not applicable to this Section.

PART 3 - EXECUTION

3.1 CONTRACTOR STAGING AREA REQUIREMENTS
   A. Contractor Staging Areas: Refer to reference drawings included in the set of Contract Drawings for location of Contractor Staging Areas.
1. Contractor shall use only site areas designated specifically by Campus as Contractor Staging Area for the Project.
2. Contractor Staging Area for the Project shall be clearly demarcated. Contractor shall remove equipment placed or located outside of areas designated for Contractor Staging Area to within Contractor Staging Area at no change in Contract Time and Contract Sum.
3. Contractor shall keep access to Contractor Staging Areas and other construction accessways and thoroughfares clear at all times. Contractor shall provide traffic and parking control signage acceptable to Campus Representative.
4. Contractor shall provide temporary, screened security fencing at staging area perimeters unless otherwise directed by the Campus Representative.

B. Cleanliness: Contractor shall keep Contractor Staging Area clear of trash and debris and in neat order. Contractor shall be responsible for cleanliness and order of assigned Contractor Staging Areas, as acceptable to Campus Representative.

3.2 REMOVAL OF CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

A. Removal of Construction Facilities and Temporary Controls: Unless otherwise mutually agreed by Campus Representative and Contractor, Contractor shall remove temporary materials, equipment, services, and construction prior to Contract Completion review.

B. Cleaning and Repairs: Contractor shall clean and repair damage caused by installation or use of temporary facilities on public and private rights-of-way.

C. Removal of Temporary Utilities and Restoration: Contractor shall remove temporary underground utility installations to a depth of two feet. Backfill, compact, and regrade site as necessary to restore areas or to prepare for indicated paving and landscaping.

END OF SECTION 015250
SECTION 015410 - SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SECTION INCLUDES

A. Contractor Security requirements per campus standards and direction. Coordinate all activities with campus police.

1.3 RELATED SECTIONS

A. All contract documents.

1.4 SECURITY

A. In addition to security requirements contained in the Contract General Conditions, Contractor shall adhere to the following requirements for security:

1. Contractor shall protect the Work from theft, vandalism an unauthorized entry. Contractor shall have sole responsibility for job site security.
2. Contractor shall maintain security throughout construction until the Campus’ occupancy or acceptance.
3. Keying: Contractor shall provide construction keying different from permanent keying of locks and include organized, locked and supervised storage for receiving and dispensing items of finish hardware throughout the construction.
4. Provide Inspector Access: Contractor shall provide the Project Inspector with keys necessary to gain access to locked areas of the Work. The Project Inspector will be responsible for such keys and will return them to the Contractor upon acceptance of the project or area as complete.

1.5 ENTRY CONTROL

A. Contractor shall restrict entrance of persons and vehicles into project site to authorized persons with proper identification.

B. Contractor shall allow building entrance only to authorized persons with proper identification.
1.6 PERMANENT KEYS

A. Immediately upon receipt of permanent keys for whatever purpose (finish hardware, mechanical equipment, casework, dispensers, lockers, switches, equipment items, etc.), Contractor shall tag or otherwise clearly identify keys according to one approved system and turn them over to the Campus Representative prior to any opportunity of access to keys by parties other than the Campus.

PART 2 - PRODUCTS

Not applicable to this Section.

PART 3 - EXECUTION

Not applicable to this Section.

END OF SECTION 015000
SECTION 015500 – VEHICULAR ACCESS AND PARKING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Construction Drawings, Technical Specifications, and general provisions of the Contract, including Contract General Conditions and Supplementary General Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SECTION INCLUDES
   A. Requirements for vehicular access to Work areas
   B. Requirements for construction parking

1.3 RELATED SECTIONS
   A. All contract documents.

1.4 PROTECTION OF EXISTING CONDITIONS
   A. Protection of Adjacent Facilities: Contractor shall restrict Work to limits indicated on the Drawings and as specified in Section 011000 “Summary of the Work.” Contractor shall protect existing, adjacent facilities from damage, including soiling and debris accumulation.

1.5 SITE ACCESS
   A. Site Access: Use of designated existing on-site streets and driveways for construction traffic is permitted. Contractor shall review access routes with Campus Representative and comply with Campus Representative’s directions.

1. Contractor shall ensure that tracked vehicles shall not use paved areas.
2. Contractor shall provide unimpeded access for emergency vehicles in accordance with local fire and police department standards and direction. Contractor shall maintain 20-foot width driveways with turning space between and around combustible materials.
3. Contractor shall provide and maintain access to fire hydrants free of obstructions.
4. Contractor shall clean and restore paving and other site features after construction use.

B. Traffic Control:
1. Contractor shall comply with all on-campus traffic regulations, including speed limits. Contractor shall pay all parking and traffic fines.

2. Blockage of site roadways and access to site parking lots and parking structures shall be only with approval of Campus Representative. Contractor shall comply with Campus’ restrictions on blocking roadways and parking areas.

3. Contractor shall employ trained and equipped flag persons to regulate traffic when construction operations or traffic encroach on vehicular and pedestrian traffic lanes.

4. Contractor shall provide signage, cones and other suitable devices to direct traffic. Contractor shall use flares and lights during hours of low visibility to delineate traffic lanes and to guide traffic.

5. Large vehicles shall have Campus public safety escort. Contractor shall provide minimum 48 hours written notice through Campus Representative.

6. Contractor shall comply with the requirements of any campus department.

1.6 TRAFFIC SIGNS AND SIGNALS

A. Traffic Signs and Signals: Contractor shall provide temporary signs and signals as required by authorities having jurisdiction and in compliance with Campus’ requirements transmitted through Campus Representative. Contractor shall relocate signs and signals as necessary during construction. Refer to Campus Environmental Health & Safety requirements.

1.7 CONSTRUCTION PARKING

A. Construction Parking:

1. Contractor shall not park on public roadways unless approved by campus police and fire authorities.

2. Contractor shall maintain clear access ways and parking for emergency vehicles, as required by campus police and fire authorities.

3. Contractor shall park on-site for loading, unloading and construction purpose only. Personal vehicles are not allowed.

4. Contractor shall obtain and pay for parking permits for on-campus parking, including use permits for campus parking lots.

PART 2 - PRODUCTS

Not applicable to this Section.
3.1 MAINTENANCE OF PARKING AND ACCESS ROADS

A. Maintenance: Contractor shall maintain traffic and parking areas in a sound condition. Contractor shall repair breaks, potholes, low areas, standing water and other deficiencies, to maintain paving and drainage in original or specified condition.

B. Cleaning of Roadways and Parking Areas: Contractor shall keep public and private rights-of-way and parking areas clear of construction-caused soiling, dust and debris, especially debris hazardous to vehicle tires.

END OF SECTION 015500
SECTION 017300 – EXECUTION REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SECTION INCLUDES

A. General requirements for installing, applying and placing products.

B. General requirements for correction of defective Work.

1.3 RELATED SECTIONS

A. All contract documents.

1.4 EXECUTION

A. Manufacturer's Requirements: Contractor shall determine product manufacturer's requirements and recommendations prior to commencing Work.

B. Execution: Contractor shall perform installation, application and placement actions according to manufacturer's instructions and recommendations and according to specified procedures.

1. Contractor shall perform surface preparation as necessary to create suitable substrates for application, installation and placement of products.

2. Contractor shall notify Campus Representative in writing of unsuitable conditions preventing proper performance of the Work.

PART 2 - PRODUCTS

Not Applicable to this Section.
PART 3 - EXECUTION

3.1 INSTALLATION, APPLICATION AND PLACEMENT OF PRODUCTS

A. Manufacturer's Instructions: Contractor shall comply with manufacturer's written instructions and recommendations for installing, applying, placing and finishing products.

B. Installation, Application and Placement, General: Contractor shall locate the Work and components of the Work accurately, in correct alignment, orientation and elevation, as indicated.

1. Contractor shall make vertical work plumb and make horizontal work level.
2. Where space is limited, Contractor shall install components to maximize space available for maintenance and ease of removal for replacement.
3. Contractor shall conceal pipes, ducts, and wiring in finished areas, unless otherwise indicated.
4. Contractor shall maintain minimum headroom clearance of 8 feet in spaces without a suspended ceiling, unless otherwise directed.
5. Contractor shall install products at the time and under conditions that will ensure the best possible results. Contractor shall maintain conditions required for product performance until acceptance of the Work.
6. Contractor shall conduct construction operations so no part of the Work is subjected to damaging operations or loading in excess of that expected during normal conditions of occupancy.

C. Tools and Equipment: Contractor shall not use tools or equipment that produce harmful noise levels.

D. Anchors and Fasteners: Contractor shall provide anchors and fasteners as required to anchor each component securely in place, accurately located and aligned with other portions of the Work.

1. Mounting Heights: Where mounting heights are not indicated, Contractor shall mount components at heights directed by Engineer.
2. Contractor shall allow for building movement, including thermal expansion and contraction.

E. Joints: Contractor shall make joints of uniform width. Where joint locations in exposed work are not indicated, Contractor shall arrange joints for the best visual effect. Contractor shall fit exposed connections together to form hairline joints.

F. Hazardous Materials: Contractor shall use products, cleaners, and installation materials that are not considered hazardous.
G. Cleaning: Contractor shall comply with requirements as specified. See individual product Specifications Sections for specific cleaning procedures to be performed.

H. Protection: Contractor shall provide barriers, covers and other protective devices as recommended by manufacturer and complying with general requirements as specified.

1. Contractor shall comply with manufacturer’s written instructions for temperature and relative humidity.
2. See individual product Specifications Sections for specific protective measures to be provided.

I. Limiting Exposures: Contractor shall supervise construction operations to assure that no part of the construction, completed or in progress, is subject to harmful, dangerous, damaging, or otherwise deleterious exposure during the construction period.

3.2 OWNER-INSTALLED PRODUCTS

A. Site Access: Contractor shall provide access to Project site for Campus’ construction forces and those performing work for Campus under separate contracts. Contractor shall coordinate with requirements specified in Section 015500 “Vehicular Access and Parking.”

B. Coordination: Contractor shall coordinate construction and operations of the Work with work performed by Campus by separate contract or with Campus’ construction forces.

1. Construction schedule: Contractor shall inform Campus Representative of Contractor’s preferred construction schedule for Campus-installed work. Contractor shall adjust construction schedule based on a mutually agreeable timetable. Contractor shall notify Campus Representative if changes to schedule are required due to differences in actual construction progress.
2. Pre-installation and coordination conferences: Contractor shall include Campus’ construction forces at pre-installation and coordination conferences covering portions of the Work that are to receive Campus-installed work. If portions of the Work depend on Campus-installed products, Contractor shall attend pre-installation conferences conducted by Campus’ construction forces.

3.3 CORRECTION OF THE WORK

A. Correction of the Work, General: Contractor shall repair or remove and replace defective construction. Contractor shall restore damaged substrates and finishes to match original and new surrounding construction.

1. Contractor shall comply with requirements as specified.
2. Repairing shall include replacing defective parts, refinishing damaged surfaces, touching up with matching materials, and properly adjusting operating equipment.
3. Contractor shall remove and replace damaged surfaces that are exposed to view if surfaces cannot be repaired without visible evidence of repair.
4. Contractor shall repair components that do not operate properly. Remove and replace operating components that cannot be repaired.
5. Contractor shall remove and replace chipped, scratched, and broken glass.

B. Restoration of Existing Conditions: Contractor shall restore permanent facilities used during construction to their original condition and in compliance with campus standards.

C. Asphalt and roadway restoration shall be done in a manner that does not produce any undulations, noticeable surface discontinuities and/or mis-leveling. Any perceivable visual or sensory restoration of surface discontinuities shall be corrected to the satisfaction of campus representative.
SECTION 017320 – CUTTING AND PATCHING REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SECTION INCLUDES

A. Requirements and procedural requirements for cutting and patching, including:

1. Cutting and patching not required to be performed as part of the Work specified in other Sections.
2. Cutting and patching existing construction altered or disturbed to accommodate new construction.
3. Cutting and patching existing construction damaged or defaced during new construction as required to restore to existing or better condition at the time of award of Contract.
4. Cutting and patching required to:
   a. Install or correct non-coordinated Work.
   b. Remove and replace defective and non-conforming Work.
   c. Remove samples of installed Work for testing.

1.3 RELATED SECTIONS

A. All contract documents.

1.4 SUBMITTALS

A. Written Requests for Cutting, patching and Alteration:

1. Contractor shall submit written request in advance of cutting or alteration which affects:
   a. Structural integrity of any element of new or existing construction.
   b. Integrity of weather-exposed or moisture-resistant elements.
   c. Efficiency, maintenance, or safety of operational elements.
   d. Visual qualities of elements exposed to view in the completed construction.
   e. All cutting and patching shall match existing structural element, surfaces, vapor barrier, water sealments; and shall match existing...
finishes. If a cut or patch remains visible during final inspections, contractor shall be responsible for painting entire wall element such that the cut and patch work becomes truly invisible.

f. Existing construction not otherwise indicated to be revised by Work under the Contract.

2. Contractor shall include in requests for cutting and alteration:

   a. Identification of Project.
   b. Location and description of affected Work. Include shop drawings as necessary to identify locations and communicate descriptions.
   c. Explanation of necessity for cutting and patching.
   d. Description of proposed Work and products to be used.
   e. Alternatives to cutting and patching.
   f. Effect on existing construction.
   g. Effect on work by Campus’ construction forces or by separate contractors performing work for Campus.

3. Contractor shall include written evidence that those performing work under separate contract for Campus have been notified and acknowledge that cutting and patching work will be occurring. Contractor shall include written permission for intended cutting and patching, including scheduled times.

4. Contractor shall indicate date and time cutting and patching Work will be performed, including duration.

5. Contractor shall describe the extent of cutting and patching required and how it is to be performed.

6. Contractor shall describe anticipated results in terms of changes to existing construction; include changes to structural elements and operating components as well as changes in the building's appearance and other significant visual elements.

7. Contractor shall list products to be used and firms or entities that will perform work.

8. Contractor shall list utilities that will be disturbed or affected, including those that will be relocated and those that will be temporarily out-of-service. Contractor shall indicate how long service will be disrupted.

9. Where cutting and patching involves addition of reinforcement to structural elements, Contractor shall submit details to show how reinforcement is integrated with the original structure.

10. Approval by the Engineer to proceed with cutting and patching does not waive the Engineer's right to later require complete removal and replacement of a part of the Work found to be unsatisfactory.

11. Contractor shall minimize effects on Campus operations and on concurrent operations construction by other contractors.

1.5 QUALITY ASSURANCE

A. Requirements for Structural Work: Contractor shall not cut and patch structural elements in a manner that would reduce their load-carrying capacity or load-deflection ratio.
1. Contractor shall obtain approval from the Engineer of the cutting and patching proposal before cutting and patching.

2. Contractor shall provide x-ray services to ascertain that internal rebar, post tension tendents, or any other structural element integral to surface or wall cut is not damaged in the following structural elements:
   
a. Bearing and retaining walls  
b. Structural concrete  
c. Structural steel  
d. Lintels  
e. Timber and primary wood framing  
f. Structural decking  
g. Stair systems  
h. Miscellaneous structural metals  
i. Equipment supports  
j. Piping, ductwork, vessels and equipment

B. Operational and Safety Limitations: Contractor shall not cut and patch operating elements or safety-related components in a manner that would result in reducing their capacity to perform as intended, or result in increased maintenance, or decreased operational life or safety.

1. Contractor shall obtain approval of the cutting and patching proposal before cutting and patching the following operating elements or safety-related systems:
   
a. Primary operational systems and equipment  
b. Air or smoke barriers  
c. Water, moisture, or vapor barriers  
d. Membranes and flashings  
e. Fire protection systems  
f. Noise and vibration control elements and systems  
g. Control systems  
h. Communication systems  
i. Electrical wiring systems

C. Visual Requirements: Contractor shall not cut and patch construction exposed on the exterior or in occupied spaces, in a manner that would, in the Engineer’s opinion, reduce the building’s aesthetic qualities, or result in visual evidence of cutting and patching. Contractor shall remove and replace work cut and patched in a visually unsatisfactory manner.

D. If possible Contractor shall retain the original installer or fabricator throughout construction phases to cut and patch the following categories of exposed work, or if it is not possible to engage the original installer or fabricator, Contractor shall engage another recognized experienced and specialized firm:
   
a. Concrete finishes  
b. Masonry  
c. Stucco and ornamental plaster  
d. Acoustical ceilings
e. Painting
f. Wall covering
g. HVAC enclosures, cabinets or covers

PART 2 - PRODUCTS

2.1 PATCHING MATERIALS

A. Patching Materials, General: As required for original installation and to match surrounding construction.

1. Contractor shall provide same products or types of construction as that in existing structure, as needed to patch, extend or match existing.
2. Generally the Contract Documents will not define products or standards of workmanship present in existing construction; Contractor shall determine products by inspection and necessary testing, and determine quality of workmanship by using existing as a sample for comparison.
3. The presence of a product, finish, or type of construction requires that patching, extending or matching shall be performed as necessary to make work complete and consistent with identical standards of quality.

B. Patching at Paving: At portland cement concrete paving, Contractor shall use concrete mix with maximum 3/8-inch aggregate and minimum 3,500 psi 28-day compressive strength. Contractor shall provide dowels to existing paving and reinforce new paving with minimum No. 3 reinforcing steel bars at 16-inches on center each way. Welded wire fabric reinforcement will not be acceptable.

C. Patching of Lawns and Grasses: Contractor shall restore areas trenched, disturbed or damaged. Contractor shall provide sod or seeded planting mix, to match existing lawn or grass area.

D. Patching of Building Finish Materials: Contractor shall match existing products and finishes. Contractor shall confirm colors, patterns and textures with Engineer. Contractor shall custom cut new materials to fit and to match joint patterns with existing materials.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examination, General: Before cutting existing surfaces, Contractor shall examine surfaces to be cut and patched and conditions under which cutting and patching is to be performed. Contractor shall take corrective action before proceeding, if unsafe or unsatisfactory conditions are encountered. Contractor shall inspect existing conditions prior to commencing Work, including elements subject to damage or movement during cutting and patching.
1. Before proceeding, Contractor shall meet at the site with parties involved in cutting and patching, including asbestos abatement, mechanical and electrical trades. Contractor shall review areas of potential interference and conflict. Contractor shall coordinate procedures and resolve potential conflicts before proceeding.

2. Beginning of cutting or patching shall be interpreted to mean that existing conditions were found by Contractor to be acceptable.

3. After uncovering existing Work, Contractor shall inspect conditions affecting proper accomplishment of Work.

3.2 PREPARATION

A. Temporary Supports: Contractor shall provide supports to ensure structural integrity of the Work. Contractor shall provide devices and methods to protect other portions of Project from damage.

B. Protection: Contractor shall protect existing construction during cutting and patching to prevent damage.

C. Contractor shall provide protection from adverse weather conditions for portions of the Project that might be exposed during cutting and patching operations.

D. Contractor shall avoid interference with use of adjoining areas or interruption of free passage to adjoining areas.

E. Contractor shall take all precautions necessary to avoid cutting existing pipe, conduit or ductwork serving the building, but scheduled to be removed or relocated until provisions have been made to bypass them.

F. Weather Protection: Contractor shall provide protection from elements for areas which may be exposed by uncovering Work. Contractor shall maintain excavations free of water.

3.3 CUTTING AND PATCHING

A. Cutting and Patching, General: Contractor shall execute cutting, fitting, and patching, excavation and fill, as necessary to complete the Work. Contractor shall employ skilled workers to perform cutting and patching. Contractor shall proceed with cutting and patching at the earliest feasible time and complete without delay. Contractor shall:

1. Coordinate installation or application of products for integrated Work. Avoid having to cut and patch new substrates and finishes.
2. Uncover completed Work as necessary to install or apply products out of sequence.
3. Cut, remove and replace defective and non-conforming Work.
4. Cut and patch as necessary to provide openings in the Work for penetration of plumbing, fire protection, HVAC and electrical Work.
5. Where partitions are removed, patch floors, walls, and ceilings with finish materials to match existing.
   a. Where removal of partitions results in adjacent spaces becoming one, re-work floors and ceilings to provide smooth and clean planes without breaks, steps, or bulkheads.
   b. Where extreme change of plane of one inch or more occurs, request instructions from Engineer as to method of making transition.

6. Trim and refinish existing doors as necessary to clear new floor finishes.

7. By-pass utility services such as pipe or conduit, before cutting, where services are shown or required to be removed, relocated or abandoned. Cut-off pipe or conduit in walls or partitions to be removed. Cap, valve or plug and seal the remaining portion of pipe or conduit to prevent entrance of moisture or other foreign matter after by-passing and cutting.

B. Cutting: Contractor shall:

1. Cut existing construction using methods least likely to damage elements to be retained or adjoining construction. Where possible review proposed procedures with the original installer; comply with the original installer's recommendations. Provide appropriate surfaces to receive final finishing.

2. Execute cutting and patching of weather-exposed, moisture-resistant elements and surfaces exposed to view by methods to preserve weather, moisture and visual integrity.

3. Cut rigid materials using carbide tip saw blades, diamond grit abrasive saw blades, diamond core drills and hole saws, and similar cutters for smooth edges. Do not overcut corners.
   a. Core drill holes through concrete and masonry.
   b. Pneumatic tools will not be allowed without prior approval.

4. Provide fire and smoke seals at new penetrations to maintain fire rating at all penetrations.

C. Patching: Contractor shall patch with durable seams that are as invisible as possible. Contractor shall comply with specified tolerances. Contractor shall restore substrates and finishes with products to match existing construction and as specified in product Sections of the Specifications for new construction. Contractor shall:

1. Where feasible, inspect and test patched areas to demonstrate integrity of the installation.

2. Restore exposed finishes of patched areas and extend finish restoration into retained adjoining construction in a manner that will eliminate evidence of patching and refinishing.

3. Where removal of walls or partitions extends one finished area into another, patch and repair floor and wall surfaces in the new space to provide an even surface of uniform color and appearance. Remove
existing floor and wall coverings and replace with new materials, if necessary to achieve uniform color and appearance.

a. Where patching occurs in a smooth painted surface, extend final paint coat over entire unbroken containing the patch, after the patched area has received primer and second coat.

4. Patch, repair or re-hang existing ceilings as necessary to provide an even plane surface of uniform appearance.
5. Finish surfaces flush and textured to match surrounding finishes.
6. Fit work neat and tight allowing for expansion and contraction.
7. Butt new finished to existing exposed structure, pipes, ducts, conduit, and other penetrations through surfaces.

D. Finishing: Contractor shall refinish surfaces to match adjacent and similar finishes as used for the Project.

1. For continuous surfaces, Contractor shall refinish to nearest intersection or natural break.
2. For an assembly, Contractor shall refinish entire unit.

E. Penetrations at Fire-Rated Construction: At penetrations of fire rated walls, partitions, ceiling, or floor construction, Contractor shall completely seal voids with firestopping and smoke seal material in compliance with an applicable UL-listed assembly, to full thickness of the penetrated element. Refer to Mechanical and Electrical Divisions.

F. Restoration and Finishing: Contractor shall finish surfaces to match adjacent and similar finishes as used for the Project.

1. Contractor shall restore Work with new products as specified in individual product Specifications Sections.
2. Contractor shall patch and replace any portion of an existing finished surface which is found to be damaged, lifted, discolored, or shows other imperfections, with matching material. Contractor shall:
   a. Provide adequate support of substrate prior to patching the finish.
   b. Refinish patched portions of painted or coated surfaces in a manner to produce uniform color and texture over the entire surface.
   c. When existing surface finish cannot be matched, refinish entire surface to nearest intersections.

G. Transition from Existing to New Construction:

1. When new work abuts or finishes flush with existing work, Contractor shall make a smooth and clean transition. Patched work shall match existing adjacent work in texture and appearance so that the patch or transition is invisible at a distance of five feet.
2. When finished surfaces are cut in such a way that a smooth and clean transition with the new work is not possible, Contractor shall notify Engineer. Contractor shall terminate existing surface in a neat manner
along a straight line at a natural line of division, and provide trim appropriate to finished surface, or as otherwise directed by Engineer.

H. Plaster Installation: Contractor shall comply with manufacturer’s instructions and install thickness and coats as indicated.

3.4 CLEANING

A. Cleaning: Contractor shall thoroughly clean areas and spaces where cutting and patching is performed or used as access. Contractor shall remove completely paint, mortar, oils, putty and items of similar nature. Contractor shall thoroughly clean piping, conduit and similar features before painting or other finishing is applied. Contractor shall restore damaged pipe covering to its original condition.

END OF SECTION 017320
PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Construction Drawings, Technical Specifications, and general provisions of the Contract, including Contract General Conditions and Supplementary General Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SECTION INCLUDES
   A. Cleaning during construction.
   B. Cleaning for Contract Completion review and final acceptance of the Work.

1.3 RELATED SECTIONS
   A. All contract documents.

1.4 SUBMITTALS
   A. Product List: Contractor shall submit complete list of all cleaning agents and materials for Campus Representative's review and approval.
   B. Cleaning Procedures: Contractor shall submit description of cleaning processes, agents and materials to be used for final cleaning of the Work. Processes and degree of cleanliness shall be as directed by Campus Representative. All cleaning processes, agents and materials shall be subject to Campus Representative's review and approval.

1.5 QUALITY ASSURANCE
   A. Cleaning and Disposal Requirements, General: Contractor shall conduct cleaning and disposal operations in compliance with all applicable codes, ordinances and regulations, including environmental protection laws, rules and practices.
   B. Cleaning Workers: Contractor shall employ experienced workers or professional cleaners for final cleaning. Contractor shall clean each surface or unit to the condition expected in a normal, commercial building cleaning and maintenance program. Contractor shall comply with manufacturer's instructions.
PART 2 - PRODUCTS

2.1 MATERIALS

A. Cleaning Agents and Materials: Contractor shall use only those cleaning agents and materials which will not create hazards to health or property and which will not damage or degrade surfaces. Contractor shall:

1. Use only those cleaning agents, materials and methods recommended by manufacturer of the material to be cleaned.
2. Use cleaning materials only on surfaces recommended by cleaning agent manufacturer.

PART 3 - EXECUTION

3.1 CLEANING DURING CONSTRUCTION

A. Contractor shall thoroughly clean data center raised floor under walk tile area with professional vacuum equipment equipped with MERV-8 HEPA filter. This process shall be performed before construction of any elements and post construction of all elements.

B. Garbage Control: Contractor shall control accumulation of debris, waste materials and rubbish. Periodically, Contractor shall dispose of debris, waste and rubbish off-site in a legal manner.

C. Cleaning, General: Contractor shall clean sidewalks, driveways and streets frequently to maintain public thoroughfares free of dust, debris and other contaminants.

D. Cleaning of Existing Facilities: Contractor shall clean surfaces in existing buildings where alteration and renovation Work is being performed or where other construction activities have caused soiling and accumulation of dust and debris. Contractor shall:

1. Clean dust and soiling from floor surfaces.
2. Clean dust from horizontal and vertical surfaces, including lighting fixtures.
3. Clean HVAC filters.

E. Parking Area Cleaning: Contractor shall keep parking areas clear of construction debris, especially debris hazardous to vehicle tires.

F. Thoroughfare Clearing and Cleaning: Contractor shall keep site accessways, parking areas and building access and exit facilities clear of mud, soiling and debris. Contractor shall:
1. Remove mud, soil and debris and dispose in a manner which will not be injurious to persons, property, plant materials and site.
2. Comply with runoff control requirements stated above and as required by governing authorities having jurisdiction.

G. Cleaning Frequency: At a minimum, Contractor shall clean Work areas daily.

H. Failure to Clean: Should cleaning by Contractor not be sufficient or acceptable to Campus Representative, especially regarding paths of travel, Campus may engage cleaning service to perform cleaning and deduct costs for such cleaning from sums owed to Contractor.

3.2 CONTRACT COMPLETION REVIEW CLEANING, GENERAL

A. Contract Completion Review Cleaning, General: Contractor shall execute a thorough cleaning prior to Contract Completion review by Campus Representative and Engineer. Contractor shall complete final cleaning before submitting final Application for Payment. Contractor shall:

1. Conduct cleaning in compliance with regulations of authorities having jurisdiction and industrial safety standards for cleaning.
2. Employ professional building cleaners to thoroughly clean building.
3. Complete cleaning operations specified below before requesting inspection for Certification of Completion. Contractor shall:

a. Clean exposed exterior and interior hard-surfaced finishes to a dust-free condition, free of stains, films and similar foreign substances. Restore reflective surfaces to their original reflective condition. Leave concrete floors broom clean. Vacuum carpeted surfaces.

b. Wipe surfaces of mechanical and electrical equipment. Remove excess lubrication and other substances. Clean plumbing fixtures to a sanitary condition. Clean light fixtures and lamps. Clean the site, including landscape development areas, of rubbish, litter and foreign substances.

c. Sweep paved areas broom clean; remove stains, spills and other foreign deposits.

B. Waste Disposal, Contractor shall:

1. Remove waste materials from the site and conduct disposal in a lawful manner.
2. Do not burn waste materials.
3. Do not bury debris or excess materials on the Campus property.
4. Do not discharge volatile, harmful or hazardous materials into drainage systems.
5. Where extra materials of value remaining after completion of associated work have become the Campus’ property, arrange for disposition of these materials as directed.
3.3 INTERIOR CLEANING

A. Interior Cleaning, Contractor shall:

1. Clean each surface or unit to the condition expected in a normal, commercial building cleaning and maintenance program.
2. Remove labels that are not permanent labels.
3. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from all visible interior and exterior surfaces.
4. Remove dust from all horizontal surfaces not exposed to view, including light fixtures, ledges and plumbing fixtures.
5. Clean all horizontal surfaces to dust-free condition, including tops of door and window frames, tops of doors and interiors of cabinets and casework.
6. Remove waste and surplus materials, rubbish and temporary construction facilities, utilities and controls.

B. Accessories and Fixtures Cleaning: Contractor shall clean building accessories, including toilet partitions, fire extinguisher cabinets, lockers and toilet accessories, all plumbing fixtures and all lighting fixture lenses and trim.

C. Metalwork: Contractor shall clean and buff all metalwork, to be free of soiling and fingerprints. Mirror finished metalwork shall be buffed to high luster.

D. Floor Cleaning: Contractor shall clean floors to dust-free condition, free of stains, films and similar foreign substances.

1. Exposed concrete floors: Contractor shall thoroughly sweep and wet mop floors in enclosed spaces. Contractor shall mop concrete floors and, at concrete floors in occupied spaces, apply floor finish as specified for resilient flooring. At unoccupied spaces, Contractor shall leave concrete floors broom clean.
2. Ceramic tile flooring: Contractor shall thoroughly sweep and mop tile flooring. Contractor shall comply with specific requirements in tile and installation materials manufacturers for cleaning materials.
3. Resilient flooring: Contractor shall thoroughly sweep all resilient flooring. Contractor shall damp wash and wax (as appropriate) all resilient flooring. Contractor shall comply with specific requirements in applicable resilient flooring Sections, and notes of the Drawings.
4. Carpet cleaning: Contractor shall comply with accepted industry practices for cleaning commercial carpet, subject to review and acceptance by Campus Representative. Contractor shall vacuum, spot clean and generally clean carpet using commercial carpet cleaning solution, scrubbers and solution extraction-type vacuuming equipment.

E. Ventilation System Cleaning: Contractor shall replace filters and clean heating and ventilating equipment used for temporary heating, cooling and ventilation.
3.4 EXTERIOR CLEANING

A. Building Exterior Cleaning: Contractor shall clean exterior of adjacent facilities where construction activities have caused soiling and accumulation of dust and debris. Contractor shall:

1. Remove labels that are not permanent labels.
2. Wash down exterior surfaces to remove dust.
3. Clean exterior surfaces of mud and other soiling.
4. exterior side of windows, storefronts and curtainwalls, including window framing.

B. Site Cleaning: Contractor shall broom clean exterior paved surfaces. Contractor shall rake clean other surfaces of the grounds. Contractor shall:

1. Wash down and scrub where necessary all paving soiled as a result of construction activities.
2. Thoroughly remove mortar droppings, paint splatters, stains and adhered soil.
3. Remove from the site all construction waste, unused materials, excess soil and other debris resulting from the Work. Legally dispose of waste.

3.5 PEST CONTROL

A. Pest Control: Contractor shall engage an experienced, licensed exterminator to inspect and rid the project area of insects, rodents and other pests.

1. Exterminator shall prepare and submit report of inspection and extermination.
2. Extermination materials shall comply with applicable pest control regulations and not leave toxic residue harmful to humans.

3.6 CLEANING INSPECTION

A. Cleaning Inspection: Prior to Final Payment or acceptance by Campus for partial occupancy or beneficial use of the premises, Contractor and Campus Representative shall jointly conduct an inspection of interior and exterior surfaces to verify that entire Work is acceptably clean.

B. Inadequate Cleaning: Should final cleaning be inadequate, as determined by Campus Representative, and Contractor fails to correct conditions, Campus may engage cleaning service under separate contract and deduct cost from Contract Sum.

END OF SECTION 017400
SECTION 017500 – STARTING AND ADJUSTING PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Construction Drawings, Technical Specifications, Addenda, and general provisions of the Contract, including Contract General Conditions and Supplementary General Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SECTION INCLUDES
   A. Starting systems.
   B. Demonstration and instructions.
   C. Testing, adjusting, and balancing.

1.3 RELATED SECTIONS
   A. All contract documents.

1.4 STARTING SYSTEMS
   A. Contractor shall coordinate schedule for start-up of various equipment and systems.
   B. Contractor shall notify Campus Representative, Engineer. Commissioning Agent and Project Inspector in writing at least seven calendar days prior to start-up of each item.
   C. Contractor shall verify that each piece of equipment or system has been checked for proper lubrication, drive rotation, belt tension, control sequence, and for conditions which may cause damage.
   D. Contractor shall verify tests, meter readings, and specified electrical characteristics agree with those required by the equipment or system manufacturer.
   E. Contractor shall verify that wiring and support components for equipment are complete and tested.
   F. Contractor shall execute start-up under supervision of applicable manufacturer's representative and/or Contractor’s personnel in accordance with manufacturer’s instructions.
G. When specified in individual specification Sections, Contractor shall require manufacturer to provide authorized representative to be present at site to inspect, check, and approve equipment or system installation prior to start-up, and to supervise placing equipment or system in operation.

H. Contractor shall submit a written report in accordance with the Submittals Procedures section that equipment or system has been properly installed and is functioning correctly.

1.5 DEMONSTRATION AND INSTRUCTIONS

A. Contractor shall demonstrate operation and maintenance of Products to Campus’ personnel at least two weeks prior to date of Contract Completion review.

B. Contractor shall demonstrate Project equipment and instruct in a classroom environment located at the Campus. The instruction shall be done by a qualified manufacturers' representative who is knowledgeable about the Project.

C. For equipment or systems requiring seasonal operation, Contractor shall perform demonstration for other season within six months of completion or, if possible, artificially create a load in the building.

D. Contractor shall utilize operation and maintenance manuals as basis for instruction. Contractor shall review contents of manual with Campus' personnel in detail to explain all aspects of operation and maintenance.

E. Contractor shall demonstrate start-up, operation, control, adjustment, troubleshooting, servicing, maintenance, and shutdown of each item of equipment at scheduled agreed time and at equipment/designated location.

F. Contractor shall prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.

G. The amount of time required for instruction on each item of equipment and system is that specified in individual sections. If no time is specified in individual sections, Contractor shall include in his/her bid sum a reasonable sum to perform instruction to the satisfaction of the Campus.

1.6 TESTING, ADJUSTING, AND BALANCING

A. Testing Agency: Contractor shall appoint, employ, and pay for services of an independent firm to perform testing, adjusting and balancing.

B. Reports will be submitted by the independent firm to Campus Representative, Engineer, Commissioning Agent and Project Inspector indicating observations and results of tests and indicating compliance or non-compliance with the requirements of the Contract Documents.
C. Campus reserves the right to hire its own independent testing and balancing company to check the work and the report submitted by the Contractor’s testing and balancing firm.

PART 2 - PRODUCTS

Not Applicable to this Section.

PART 3 - EXECUTION

Not Applicable to this Section.

END OF SECTION 017500
SECTION 017700 - CLOSEOUT PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Construction Drawings, Technical Specifications, Addenda, and general provisions of the Contract, including Contract General Conditions and Supplementary General Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SECTION INCLUDES
   A. Contract closeout procedures, including Contract Closeout meetings, correction ("punch") lists, submittals and final payment procedures.

1.3 RELATED SECTIONS
   A. All contract documents.

1.4 FINAL COMPLETION ACTIONS
   A. Contractor Responsibility: Contractor shall be solely responsible for the timely completion of all required Contract closeout items except for filing of Notice of Completion by the Trustees.
   B. Warranties, Bonds and Certificates: Contractor shall submit specific warranties, guarantees, workmanship bonds, maintenance agreements, final certifications and similar documents.
   C. Locks and Keys: Contractor shall change temporary lock cylinders over to permanent keying and transmit keys to Trustees, unless otherwise directed or specified.
   D. Tests and Instructions: Contractor shall complete start-up testing of systems, and instruction of the Campus’ personnel. Contractor shall remove temporary facilities from the site, along with construction tools, mock-ups, and similar elements.

1.5 CONTRACT COMPLETION REVIEW
   A. Contractor’s Notification for Contract Completion Review Meeting: When the Contractor determines that the Work is complete in accordance with Contract Documents, the Contractor shall submit to Campus Representative and Engineer written certification that the Contract Documents have been reviewed,
the Work has been inspected by the Contractor and by authorities having jurisdiction, and the facility is ready for the Contract Completion review.

B. Contract Completion Review Meeting: Campus Representative and, as authorized by the Trustees, Engineer and Trustees’ representatives and consultants, as appropriate, will attend a meeting at the Project site to review Contract closeout procedures and to review the items to be completed and corrected Punch List to make the Work ready for acceptance by the Trustees. This meeting shall be typically scheduled four to six weeks prior to scheduled completion date.

C. Punch List: Engineer shall prepare subsequent to the Contract completion review meeting, a comprehensive list of items to be completed and corrected (Punch List) to make the Work ready for acceptance by the Trustees.

1. The Punch List shall include all items to be completed or corrected prior to the Contractor's application for final payment.
2. The Punch List shall identify items by location (room number or name) and itemized number.
3. Engineer and consultants shall prepare separate lists according to categories used for Drawings. For example, provide lists for Engineering, Structural, Mechanical (HVAC), Plumbing, Fire Protection (sprinkler) system, Electrical and Equipment. All lists shall be compiled by the Engineer into the all inclusive Master Punch List.
4. Items to be considered shall include but not be limited to:
   a. Corrections to construction.
   b. Operation and maintenance data (manuals).
   c. HVAC testing and balancing reports.
   d. Spare parts and extra materials.
   e. Keys, permanent keying and lock cylinders.
   f. Warranties and guaranties.
   g. Project record Drawings and Specifications.
   h. Project record construction schedule.
   i. State Fire Marshal Inspection.
   j. Other regulatory inspections.
   k. Removal of construction facilities and temporary controls.
   l. Final cleaning and pest control.
   m. Landscape maintenance.
   n. Commissioning/equipment startup.
   o. Demonstration and training.
   p. Acceptance.
   q. Notice of Completion, filing by Trustees.
   r. Final application for payment.
   s. Occupancy by Campus.
   t. Other closeout items specified.

D. Contract Completion Meeting: On a date mutually agreed by Campus Representative, Engineer and Contractor, a meeting shall be conducted at the Project site to determine whether the Work is satisfactory and has achieved Contract Completion.
1. Contractor shall provide a minimum seven calendar days written notice to the Campus Representative and Engineer for requested date of Contract Completion meeting.
2. Engineer will attend the Contract Completion meeting.
3. In addition to conducting a walk-through of the facility and reviewing the Punch List, the purpose of the meeting shall include submission of warranties, guarantees and bonds to Campus, submission of operation and maintenance data (manuals), provision of specified extra materials to Campus, and submission of other Contract closeout documents and materials as required and if not already submitted.
4. Engineers, as appropriate, will conduct a walk-through of the facility with the Campus Representative and Contractor to review the Punch List.
5. Engineer shall update the Punch List and record additional items as may identified during the walkthrough, including notations of corrective actions to be taken.
6. Engineer shall revise the Punch List and distribute it within five calendar days to those attending the meeting.

E. Uncorrected Work: Refer to requirements specified in Section 014500 “Quality Control” regarding Contract adjustments for non-conforming Work.

F. Clearing and Cleaning: Prior to the Contract Completion review meeting, Contractor shall conduct a thorough cleaning and clearing of the Project area, including removal of construction facilities and temporary controls. Refer to Section 017400 “Cleaning Requirements.”

G. Inspection and Testing: Prior to the Contract Completion review meeting, Contractor shall complete inspection and testing required for the Work, including securing of approvals by authorities having jurisdiction.

1. Complete all inspections, tests, balancing, sterilization and cleaning of plumbing and HVAC systems.
2. Complete inspections and tests of electrical power and signal systems.

H. Notice of Completion: Campus will record the Notice of Completion with County Recorder, when the Project is complete in all respects.

1.6 FINAL COMPLETION SUBMITTALS

A. Final Completion Submittals: Prior to application for Final Payment, Contractor shall submit the following.

B. Agency Document Submittals: Contractor shall submit to Campus all documents required by authorities having jurisdiction, including serving utilities and other agencies. Contractor shall submit original versions of all permit cards, with final sign-off by inspectors. Submit all certifications of inspections and tests.
C. Final Specifications Submittals: Contractor shall submit to Campus all documents and products required by Specifications to be submitted, including the following:

1. Project record drawings and specifications.
2. Operating and maintenance data.
4. Keys and keying schedule.
5. Spare parts and extra stock.
6. Test reports and certificates of compliance.

D. Certificates of Compliance and Test Report Submittals: Contractor shall submit to Campus Representative certificates and reports as specified and as required by authorities having jurisdiction, including but not limited to the following:

1. Sterilization of water systems.
2. Sanitary sewer system tests.
3. Gas system tests.
4. Lighting, power and signal system tests.
5. Ventilation equipment and air balance tests.
6. Fire sprinkler system tests.
7. Roofing inspections and tests.

E. Subcontractors List: Contractor shall submit two copies of updated Subcontractor and Materials Supplier List to Campus Representative and one copy to Engineer.

F. Warranty Documents: Contractor shall prepare and submit to Campus all warranties.

G. Service Agreements and Service Contracts: Contractor shall submit to Campus Representative.

1.7 FINAL PAYMENT

A. Final Payment: After completion of all items listed for completion and correction and after submission of all documents and products and after final cleaning, Contractor shall submit final Application for Payment, identifying total adjusted Contract Sum, previous payments and sum remaining due. Payment will not be made until the following are accomplished:

1. All Project Record Documents have been received and accepted by the Engineer.
2. All extra materials and maintenance stock have been transferred and accepted by Campus.
3. All warranty documents and operation, maintenance data, service agreements, maintenance contracts and salvage materials have been received and accepted by Campus Representative.
RIO HONDO COLLEGE
EMERGENCY GENERATOR AND DATA CENTER HVAC UPGRADES

PART 2 - PRODUCTS

Not Applicable to this Section.

PART 3 - EXECUTION

Not Applicable to this Section.

END OF SECTION 017700
PART 1 - GENERAL

1.1 SUMMARY
   A. This Section specifies reinforcement for cast-in-place concrete for the following:
   B. Section includes:
      1. Formwork for cast-in-place concrete with shoring bracing and anchorage except as specified below.
      2. Openings for other affected work.
      3. Form accessories.
      4. Stripping forms.

1.2 SYSTEM DESCRIPTION
   A. Design, engineer, and construct formwork, shoring, and bracing to meet design and code requirements, so that resultant concrete conforms to required shapes, lines, and dimensions.
   B. Conform to applicable building codes.

1.3 REFERENCES
   A. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:
      1. ACI 301, "Specification for Structural Concrete."
      2. ACI 347, "Guide to Formwork for Concrete."
      3. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."

1.4 SUBMITTALS
   A. Product Data: For each type of product indicated.
   B. Shop Drawings:
      1. Prepare shop drawings under seal of a California-licensed civil engineer. Design and engineering of formwork and shoring, as well as its construction, is the responsibility of the Contractor.
      2. Submit manufacturer’s product data, specifications, typical installation details and other data as necessary to demonstrate compliance with the
specified requirements for form materials, including coatings, release agents, ties and accessories.

C. Submit manufacturer's installation instruction for void form materials and waterstops.

D. Submit a diagram of proposed construction joints. Submittal will be reviewed with respect to aesthetic criteria and for general design conformance only.

1.5 QUALITY ASSURANCE

A. Applicable referenced specifications, standards, and publications:

B. Pre-installation Conference: Conduct conference at Project site.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle materials as specified.

B. Deliver materials in manufacturer’s packaging with installation instructions.

C. Store off ground in ventilated and protected area to prevent deterioration from moisture or damage.

D. Remove packaging from void forms prior to storage.

1.7 COORDINATION

A. Notify responsible trades of schedules of concrete pours so as to allow adequate time for installation and coordination of their work.

B. Coordinate this Section with other Sections of work which require attachment of components to formwork.

C. If formwork is placed after reinforcement resulting in insufficient concrete cover over reinforcement, request instructions from Engineer before proceeding.

PART 2 - PRODUCTS

2.1 WOOD FORM-FACING MATERIALS

A. Smooth-Formed Finished Concrete: Form-facing panels that will provide continuous, true, and smooth concrete surfaces. Plywood, MDF panels, turnber, metal, or another approved material. Furnish in largest practicable sizes to minimize number of joints.
B. Rough-Formed Finished Concrete: Provide lumber dressed on at least two edges and one side for tight fit.

1. Lumber: No. 2 Grade or better with grade stamp clearly visible.
2. Use MDF facing panels where finished concrete will be exposed to view.

2.2 PREFABRICATED FORM-FACING MATERIALS

A. Preformed Steel Forms: Minimum 16 gage matched, tight fitting, stiffened to support weight of concrete without deflection detrimental to tolerances and appearance of finished surfaces.

B. Glass Fiber Fabric Reinforced Plastic Forms: Matched, tight fitting, stiffened to support weight of concrete without deflection detrimental to tolerances and appearance of finished concrete surfaces.

C. Tubular Column Type: Round, spirally wound laminated fiber material, surface treated with release agent, non-reusable, of sizes required.

D. Slab Void Forms:

1. Composition: Moisture resistant, corrugated, laminated, fiberboard; with interior fabrication of a uniform, cellular, configuration, composed of non-wax impregnated components or high compressive strength polystyrene foam or SureVoid by Falcon Manufacturing Co., Inc. SureVoid Products, Inc., or Deslauriers, Inc.
2. Depth: As indicated on drawings.
3. Profile: As indicated on drawings.
4. Strength: Capable of sustaining a working load of 1,000 psf.
5. Accessories: Of same composition and strengths as slab void forms, including the following:
   a. Column wrap.
   b. Angle expansion strip.

2.3 FORMWORK ACCESSORIES

A. Form Ties: Snap-off metal of adjustable length; cone type; 1 inch break back dimension; free of defects that will leave holes no larger than 1-1/4 inches diameter in concrete surface.

B. Form Release Agent: Colorless material which will not stain concrete, absorb moisture or affect bond of subsequent surface finish, or impair natural bonding or color characteristics of coating intended for use on concrete:
1. Acceptable Manufacturers: Subject to compliance with requirements herein, provide products from one of the following:
   a. The Burke Group, San Nanto, CA.
   b. Safe Slip by Chem-Masters, Madison, OH.
   c. Debond by L & M Construction Chemicals, Inc., Omaha, NE.
   d. Nox-Crete Form Coating by Nox-Crete, Inc., Omaha, NE.
   e. Cast-Off, Sonneborn Building Products, Minneapolis, MN.
   f. Symons Corp., Des Plaines, IL.
   g. Duogard Form Release Agent by W.R. Meadows, Inc., Elgin, IL.

C. Fillets for Chamfered Corners and other justifications: Wood strips, sizes and configurations as detailed.

D. Nails, Spikes, Lag Bolts, Through Bolts, Anchorages: Sized as required; of strength and character to maintain formwork in place while placing concrete.

E. Shores: Patented shores of approved design and manufacture, or built-up on job of structural grade timbers of adequate strength and properly braced to safely support imposed loads.

F. Form Sealer, Acceptable Products:
   1. Formfilm by W.R. Grace.
   2. Pre-Form by Nox-Crete Co.

G. Waterstop: 1 inch by 3/8 inch size, composed of butyl rubber and bentonite clay. Acceptable products:
   1. Volclay Waterstop-RX by American Colloid Co.
   2. Superstop Waterstop by Tremco, Inc.

H. Formed Construction Joints: Galvanized steel, tongue and groove type, knock-out holes spaced at 6 inches on center, with anchors.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify lines, levels, and measurements before proceeding with formwork.

B. Correct unsuitable conditions before proceeding with concrete placement.

3.2 EARTH FORMS

A. Earth forms not permitted, except for footings where soil is conducive and approval is received from authorities having jurisdiction and structural engineer.
B. Hand trim sides and bottoms of earth forms, remove loose dirt prior to placing concrete.

3.3 FORMWORK

A. Design, erect, shore, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads.

B. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.

C. Limit concrete surface irregularities, designated by ACI 347R as abrupt or gradual, as follows:
   1. Class A, 1/8 inch for smooth-formed finished surfaces including exposed ceilings.
   2. Class B, 1/4 inch for rough-formed finished surfaces.

D. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.
   1. Install keyways, reglets, recesses, and the like, for easy removal.
   2. Do not use rust-stained steel form-facing material.

3.4 ERECTION

A. Minimize form joints. Symmetrically align joints and make watertight to prevent leakage of mortar.

B. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.

C. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.

D. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.

E. Arrange forms to allow stripping without removal of principal shores, where required to remain in place.
F. Provide bracing to ensure stability of formwork. Strengthen formwork liable to be overstressed by construction loads.

G. Camber elevated slabs and beams to achieve ACI 301 tolerances.

H. Provide temporary ports in formwork to facilitate cleaning and inspection. Locate openings at bottom of forms to allow flushing water to drain. Close ports with tight fitting panels, flush with inside face of forms, neatly fitted so that joints will not be apparent in exposed concrete surfaces.

I. Provide chamfer strips on external corners of beams, and columns where they will be exposed to view after completion of construction.

J. Protect void forms from moisture before concrete placement in accordance with manufacturers’ requirements. Protect from crushing during concrete placement. Cap ends of void boxes as required. Prior to the concrete placement, replace void forms which have been damaged physically or by moisture.

K. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.

L. Construct form fully depth of concrete to be placed.

3.5 APPLICATION OF FORM RELEASE AGENT

A. Apply form release agent on formwork in accordance with manufacturer’s instructions. Apply prior to placing reinforcing steel, anchoring devices, and embedded items.

B. Do not apply form release agent where concrete surfaces are scheduled to receive applied coverings which may be affected by agent. Soak contact surfaces of untreated forms with clean water. Keep surfaces wet prior to placing concrete.

C. Do not apply form release agent where wood grain characteristics are required on finished concrete surfaces. Leave formwork dry.

3.6 INSERTS, EMBEDDED PARTS, AND OPENINGS

A. Provide formed openings where required for work embedded in or passing through concrete.

B. Locate and set in place items which will be cast directly into concrete.

C. Coordinate work of other Sections in forming and setting openings, slots, recesses, chases, sleeves, bolts, anchors, and other inserts.

D. Install accessories in accordance with manufacturer’s instructions, level and plumb. Ensure items are not disturbed during concrete placement.
E. Install waterstop in single lengths where possible. Install where detailed and wherever water penetration through construction joints is anticipated. Make provisions to support and protect water stops during progress of the work.

F. Provide temporary ports or openings in formwork where required to facilitate cleaning and inspection. Locate openings at bottom of forms to allow flushing water to drain.

G. Close temporary openings with tight fitting panels, flush with inside face of forms, and neatly fitted so joints will not be apparent in exposed concrete surfaces.

H. Install construction joint device in coordination with floor slab pattern placement sequence. Set top to required elevations. Secure to resist movement by wet concrete.

3.7 FORMWORK TOLERANCES

A. Construct formwork to maintain tolerances required by ACI 301. As a minimum requirement, support form facing material to limit deflection to L/360 between supports. For post-tensioned slabs, the formwork shall be set and supported true to the elevations as indicated on the Drawings.

B. Camber slabs and beams as indicated on the Drawings and in accordance with ACI 301.

3.8 FIELD QUALITY CONTROL

A. Inspect erected formwork, shoring, and bracing to ensure that work is in accordance with formwork design, and that supports, fastenings, wedges, ties, and items are secure.

B. Do not reuse formwork for concrete surfaces to be exposed to view. Do not patch formwork.

C. Testing requirements as specified.

3.9 FORM REMOVAL

A. Notify University Representative prior to removing formwork.

B. Do not remove forms, shoring and bracing until concrete has sufficient strength to support its own weight, and construction and design loads which may be imposed upon it. Pay for and have testing laboratory make additional test cylinders to confirm strength requirements as required for early form recovery. Presume concrete to have reached this strength when either of the following conditions are met:
   1. Method 1:
a. Test cylinders, field cured along with concrete they represent, have reached strength required for removal of formwork.
b. Except for field curing and age at test, mold and test cylinders as specified in testing.

2. Method 2:
   a. After concrete has cured for same length of time as age at test of laboratory-cured cylinders which reached specified strength.
   b. Determine length of time concrete has been cured in structure by cumulative number of days or fractions thereof, not necessarily consecutive, during which temperature of air in contact with concrete is above 50 degrees F and concrete has been damp or thoroughly sealed from evaporation and loss of moisture.

C. Perform reshoring before removing original shoring. Leave reshoring in place until members have attained required compressive strength, or as long as required to support additional construction loads. Do not remove shores until concrete is a minimum of 80 percent of 28 day strength, or as specified by Engineer.

D. Reshore structural members due to design requirements or construction conditions to permit successive construction.

E. Remove formwork progressively so no unbalanced loads are imposed on structure.

F. Do not damage concrete surfaces during form removal.

G. Store reusable forms for exposed architectural concrete to prevent damage to contact surfaces.

H. When repair of surface defects or finishing is required at early age, remove forms as soon as concrete has hardened to resist damage from removal operation.

I. Top forms on sloping surfaces of concrete may be removed as soon as concrete has attained sufficient stiffness to prevent sagging.

J. Perform needed repairs or treatment required on sloping surfaces at once and follow with curing.

K. Loosen wood forms for openings as soon as loosening can be accomplished without damage to concrete.

L. Formwork for walls, sides of beams, and other parts not supporting weight of concrete may be removed as soon as concrete has hardened sufficiently to resist damage from removal operations.
M. When shores and other vertical supports are so arranged that nonload-carrying form facing material may be removed without loosening or disturbing shores and supports, form facing material may be removed at earlier age.

N. For exposed concrete surfaces, do not reuse formwork when it has deteriorated to the point where usage will affect the finished concrete appearance. Do not patch formwork.

O. Do not place wood forms which cannot be retrieved after concrete placement. Use steel forms.

3.10 CLEANING

A. Clean forms to remove foreign matter as erection proceeds.

B. Ensure that water and debris drain to exterior through clean-out ports.

C. Use compressed air to remove foreign matter.

END OF SECTION 031100
PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies reinforcement for cast-in-place concrete for the following:

1. Footings.
2. Foundation and building walls.
3. Slabs-on-grade.
4. Suspended slabs.
5. Concrete toppings.

1.2 SUBMITTALS

A. Steel Reinforcement Shop Drawings: Placing drawings that detail fabrication, bending, and placement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement.

B. Product Data: For each type of product indicated.

C. Welding certificates.

D. Stack reinforcing steel in tiers and mark so that each length, size, shape and location can be readily determined. Exercise care to maintain reinforcement free of dirt, mud, paint or rust.

PART 2 - PRODUCTS

2.1 STEEL REINFORCEMENT

A. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 60 percent.

B. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed or unless otherwise noted.

C. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M, deformed.

D. Waste: Provide 5 percent extra for each reinforcement type of reinforcement bar required to account for waste in field assembly procedures.
2.2 REINFORCEMENT ACCESSORIES

A. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), plain-steel bars, cut bars true to length with ends square and free of burrs.

B. Zinc Repair Material: ASTM A 780, zinc-based solder, paint containing zinc dust, or sprayed zinc. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI’s "Manual of Standard Practice," of greater compressive strength than concrete and as follows:

1. For concrete surfaces exposed to view where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI Class 2 stainless-steel bar supports.
2. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.
3. For zinc-coated reinforcement, use galvanized wire or dielectric-polymer-coated wire bar supports.

2.3 FABRICATING REINFORCEMENT

A. Fabricate in accordance with ACI SP-66, providing concrete cover as specified.

B. Locate reinforcing splices not indicated on Drawings at points of minimum stress. Indicate location of splices on shop drawings.

C. Weld reinforcing bars in accordance with ANSI/AWS D 1.4.

D. Provide sufficient lap of splicing of reinforcement, where required, to permit transfer of stress in accordance with requirements of this specification. Splice wall vertical reinforcement at location of horizontal construction joints.

E. Unless otherwise noted on the drawings to be greater, lap reinforcement 36 bar diameters (class “A” lap) at splices or have dowels of same bar section and spacing as the bars to be spliced. Lap bars at least 36 diameters (class “A” lap) at corners and at abrupt changes in direction of walls. Stagger splices in adjacent bars.

F. Detail column splices so as not to interfere with beam steel.
3.1 EMBEDDED ITEMS

A. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

1. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC’s "Code of Standard Practice for Steel Buildings and Bridges."

3.2 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.

1. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that would reduce bond to concrete.

C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.

1. Weld reinforcing bars according to AWS D1.4 (latest addition), where indicated.

D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

E. Install welded wire reinforcement in longest practicable lengths on bar supports spaced to minimize sagging. Lap edges and ends of adjoining sheets at least one mesh spacing. Offset laps of adjoining sheet widths to prevent continuous laps in either direction. Lace overlaps with wire.

3.3 FIELD QUALITY CONTROL

A. Testing and Inspecting: University representative will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Inspections:

1. Steel reinforcement placement.
2. Steel reinforcement welding.
3. Headed bolts and studs.

END OF SECTION 032100
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Leveling, floating, troweling and other finishing treatments of newly-placed unformed concrete surfaces.
2. Curing of newly-placed unformed concrete surfaces.
3. Repair of newly-cured and hardened concrete.

1.2 REFERENCES

A. Definitions:

1. Newly-Placed Concrete: Means freshly placed and finished concrete during a period following final finishing operations immediately after bleed water glaze or sheen has disappeared and concrete is hard enough to resist surface damage, but before initial set, and whose surface is damp but not wet.
2. Newly-Cured Concrete: Means freshly placed and finished concrete during a period following initial set, but before final set.
3. Hardened Concrete: Means new concrete during a period following final set.
4. Aged Concrete: Means existing-to-remain concrete whose surfaces have been exposed to a weathering, abrasion, liquid penetration, freeze/thaw cycles or salts and similar contaminites.
5. Smooth: Means having a continuously even surface free from irregularities, roughness, projections, bumps, points or ridges.
6. Surface Defect: Means surface voids, form streaking, sand streaking, aggregate transparency, color variation, layer lines, spalling, cracking, cold joints, offsets, honeycomb, bugholes in excess of 5/8-diameter and similar cavities or irregularities.
7. Trowel Mark: Means a concrete surface feature produced by troweling that can be both seen and felt.
8. Trowel Pattern: Means a concrete surface feature produced by troweling that can be seen, but cannot be felt.

B. Reference Standards: Comply with American Concrete Institute (ACI) publication ACI 302.1, “Guide for Concrete Floor and Slab Construction” requirements for finishing operations concrete surfaces.
1.3 ADMINISTRATIVE REQUIREMENTS

A. Delegated Design Requirements:

1. Concrete Finishing: For concrete surfaces scheduled or indicated to receive a topping, plaster, waterproofing or other directly-applied covering materials, including adhesives, coatings and sealers specified in other Sections, coordinate concrete finishing with specified, scheduled or indicated covering material and provide concrete tolerances and surface finishes as required, recommended, approved or accepted by the selected supplier or manufacturer of the covering material.

2. Concrete Curing: When liquid membrane-forming curing compounds are selected for use in curing concrete, coordinate chemical and adhesive compatibility of selected curing compounds with selected finish materials, products and accessories specified in other Sections, including sealers, waterproofing membranes, liquid flashings, joint sealants, fluid-applied or resinous flooring, adhesives, stains, paints, coatings and similar materials that penetrate, adhere to, or otherwise come into contact with concrete surfaces that have been exposed to liquid curing compounds.

3. Remedial Work:

   a. Remedial work necessary to correct or improve defective surface finishes or tolerances shall be Contractor's responsibility.

   b. Remedial work necessary to correct or improve defective substrates or defective failures of finish material installations resulting from improper selection and application of liquid curing compounds or form release agents, as well as inadequate coordination of selected liquid curing compounds or form release agents with selected finish material, adhesive, coating, sealer or similar materials that penetrate, adhere to, or otherwise come into contact with concrete surfaces, shall be Contractor's responsibility.

1.4 SUBMITTALS

A. Product Data:

   1. Submit manufacturer's product data and specifications for liquid membrane-forming curing compounds.

   2. Jointly submit product data for finish flooring adhesives, coatings and sealers with curing compound product data.

B. Shop Drawings: Submit drawings showing locations of specified finishes. Indicate curing method and curing compounds proposed for these areas by name.

C. Certificates: Prior to beginning the work of this section, submit letter from each liquid membrane-forming curing compound manufacturer stating materials specified are compatible with materials used in the concrete mixes, and will not negatively affect concrete color, finishing characteristics, quality, durability or performance.
D. Manufacturer’s Instructions: Submit manufacturer-prepared instructions concerning the proper surface preparation and application of curing, sealing and hardening agents and curing recommendations.

1.5 QUALITY ASSURANCE

A. Source Limitations:

1. Obtain each type, composition, and variety of liquid membrane-forming curing compound used for the Project from the same manufacturer.
2. Products from more than one approved manufacturer may be used for different applications, however all products for like applications shall be by the same manufacturer.

B. Finisher’s Qualifications:

1. Individuals performing finishing operations shall be qualified as ACI-certified Flatwork Technicians and Finishers.
   a. Verify personnel to be employed in this work are current in their certification.
   b. If re-certification is required, retesting will be Contractor’s responsibility.
2. Firm and individuals with a minimum of 3 consecutive years experience in the application of specified products on projects similar in material, design, complexity and extent to this Project, and whose work has resulted in applications with a record of successful in-service performance.

C. Certifications: Submit duplicate copies of manufacturer’s affidavit with each shipment of materials delivered to the jobsite certifying that material furnished complies with specified requirements.

D. Regulatory Requirements:

1. Coefficient of friction of finished concrete flatwork shall be not less than 0.6 for level surfaces and 0.8 for ramps when tested in compliance with ASTM C 1028 (field test) or ASTM D 2047 (laboratory test).
2. Provide medium broom finish for level concrete surfaces sloped less than 6 percent; heavy broom finish for concrete surfaces sloped greater than 6 percent.

1.6 PROJECT CONDITIONS

A. Environmental Requirements: If at any time during concrete placing or curing the evaporation rate of concrete exceeds 0.2 pounds per square foot per hour, based on environmental data and concrete surface temperatures, especially when conditions of low humidity and high temperature exist, provide preventive
measure such as fog curing method in order to reduce plastic shrinkage cracks during flatwork finishing operations, or use evaporation reducer in addition to other specified finishing requirements.

1.7 SEQUENCING

A. Allow enough time in the construction schedule for mockups of concrete repairs to age a minimum of 30 days before Engineer evaluates acceptability.

B. Allow sufficient time in the construction schedule for newly-cured or re-wetted concrete to dry to a level acceptable to finish manufacturer before applying finishes or adhesives.

PART 2 - PRODUCTS

2.1 WATER AND MOISTURE CURING MATERIALS

A. Water: Fresh, clean, potable water complying with ASTM C 94 requirements, and free of oil, grease, waxy films, curing compounds, release agents and other deleterious materials that would negatively affect the quality, durability, appearance and performance of concrete.

B. Burlap Cloth: Provide mats or rugs made from jute complying with AASHTO M 182 requirements for Class 3 burlap cloth.

2.2 SHEET CURING MATERIALS

A. Curing Paper: Provide regular or white reinforced composite kraft paper complying with ASTM C 171 Standard Specification for Sheet Materials for Curing Concrete requirements, and with Federal Specification (FS) UU-B-790a requirements for Type II, concrete curing paper Grade E, moisture retentive Style 8 classification.

B. Non-Insulated Curing Tarp:

1. Description: Reusable polypropylene (PP) or vinyl-coated polyester covers.
2. Products: Provide one of the following.
   a. "Transguard 4000" by Reef Industries.
   b. "Tarps" by Hamilton Form Co, Ltd.
   c. "TVM Concrete Curing Blankets" by TVM Building Products.
   d. Or Approved Substitute.
2.3 SURFACE HARDENERS


1. Description: Ferrosilicon or quartz-silica aggregate dry-shake surface hardener.
2. Products: Provide one of the following.
   a. "Lumiplate" by BASF Building Systems.
   b. "Diamond-Plate" by Euclid Chemical Co.
   c. "Ferrocon FF" by L&M Construction Chemicals, Inc.
   d. Or Approved Substitute.

2.4 EVAPORATION REDUCERS

A. Description: Water-based polymer liquid applied to surfaces of newly-placed concrete in order to minimize rapid drying conditions due to high temperatures, low humidity, high winds or direct sunlight.

B. Products: Provide one of the following.
   1. "MBT Confilm" by BASF Building Systems.
   2. "Eucobar" by Euclid Chemical Co.
   3. "E-Con" by L&M Construction Chemicals, Inc.
   4. Or Approved Substitute.

2.5 LIQUID MEMBRANE-FORMING CURING COMPOUNDS

A. Cure-Only Compound (Type I): Not used.

B. Dissipating Curing Compound (Type II): Apply to exposed-in-service surfaces of newly-placed interior concrete slabs that will later receive epoxy or urethane based coatings, or penetrating concrete sealer.

1. Description: Water-based, VOC-compliant curing compound complying with ASTM 309 requirements for Type 1-DClear or translucent with fugitive dye, a dye that loses its coloring during proper usage, Class A or Class B classification.
2. Products: Provide one of the following.
   a. "Day-Chem Rez Cure (J-11-W)" by Dayton Superior Corp.
   b. "KUREZ DR VOX" by Euclid Chemical Co.
   c. "CURE R" by L&M Construction Chemicals, Inc.
   d. "Horncure WB 30C" by Tamms Industries, Inc.
   e. Or Approved Substitute.
C. Curing and Sealing Compound (Type III): Apply to exposed-in-service surfaces of newly-placed interior concrete slabs within telecommunications, low voltage and electrical rooms.

1. Description: Transparent, high-gloss, VOC-compliant, film-forming, acrylic blend curing and sealing compound complying with ASTM C 309 requirements for Type 1, Class B and ASTM C 1315 requirements for Type I, Class A classifications.
   b. "Super Diamond Clear VOX" by Euclid Chemical Co.
   c. "Lumiseal Plus" by L&M Construction Chemicals, Inc.
   d. Or Approved Substitute.

D. Hardening and Sealing Compound (Type IV): Apply to exposed-in-service surfaces of newly-placed interior concrete parking structure slabs and decks, and to exposed-in-service surfaces of newly-placed interior concrete stair treads and landings.

1. Description: VOC-compliant, sodium silicate-based chemical hardening and sealing compound that chemically reacts to strengthen and harden concrete.
2. Products: Provide one of the following.
   a. "Eucosil" by Euclid Chemical Co.
   b. "Chem Hard" by L&M Construction Chemicals, Inc.
   c. Or Approved Substitute.

E. Curing, Sealing, Hardening and Dustproofing Compound (Type V): Apply to concrete surfaces scheduled to receive dry-shake surface hardener, and to concealed-in-service surfaces of interior concrete slabs, decks, stair treads and landings, and other concrete flatwork surfaces scheduled to receive an applied floor finish.

1. Description: High-solids compound complying with ASTM C 309 requirements for Type 1, Class A and ASTM C 1315 requirements for Type I, Class A classifications.
2. Products: Provide "CS2000 Spray Apply System" by Creteseal, or Approved Substitute.

2.6 CONCRETE REPAIR MATERIALS

A. Horizontal Repair Material: Provide one of the following.

1. "Thin Top Supreme/Concrete Top Supreme" by Euclid Chemical Co.
2. "Sikatop 122 PLUS" by Sika Corp.
3. Or Approved Substitute.

B. Vertical and Overhead Repair Material: "Sikatop 123 PLUS" by Sika Corp. or Approved Substitute.
2.7 ACCESSORIES

A. Screeds: Provide screeding system that does not puncture below grade vapor diffusion retarder. Screed pins or screed chairs that can puncture underslab vapor diffusion retarder are not permitted.

PART 3 - EXECUTION

A. General:

1. Finish surfaces to produce uniform appearance throughout area involved and throughout adjacent areas with the same concrete finish.
2. Penetrations of vapor retarder caused by placing or finishing concrete are not permitted.

B. Compacting and Floating: Use continuous screeds of type and construction and spaced or located to produce specified surface tolerances.

1. Bring slabs to proper level using screeds and strike off with a straightedge. Remove excess water and laitance.
2. Compact and consolidate to embed coarse aggregates.
3. Float and test surfaces with a 10-foot straightedge and eliminate high and low spots to comply with specified tolerances.
4. Use methods and tools necessary to produce scheduled surface finish.

C. Concrete for Floors to be Placed over Metal Deck:

1. Use adjustable screeds at all screeded points and adjust to compensate for existing deflection and for deflection of deck and beams occurring during concreting operations. Do not use steel closures at metal deck edges as a screed.
2. Continuously monitor screeds and floors during concrete placement and finishing and adjust concrete floor thickness as required to obtain level floors complying with specified tolerances.

D. Markings: Make marking lines straight as indicated, of uniform depth and cross section, and equally spaced and parallel to adjacent lines, walls, edges and other construction with intersections accurately formed.

1. Where tooled markings are indicated, mark slabs with a 1/4-inch radiused edging or marking tool.
2. Where saw cutting is indicated, time cutting operation so cutting is performed as soon as concrete has hardened sufficiently to prevent aggregates from being dislodged by the saw, but before shrinkage stresses have developed sufficiently to produce cracking.

3.2 WOOD FLOAT FINISH

A. Description: Apply to surfaces scheduled to receive waterproofing.
B. Special Techniques: Float surfaces to a uniform texture and finish throughout acceptable to the roofing and waterproofing subcontractors.

3.3 STEEL TROWEL FINISH

A. Description: Apply to surfaces scheduled to receive resilient flooring, concrete sealer and concrete slabs that have no other specified finish.

B. Special Techniques:

1. Consolidate concrete surface by final hand troweling operation, free of trowel marks, uniform in texture and appearance, and with surface plane tolerance specified. Grind smooth surface defects that would telegraph through applied floor covering system.
2. Steel trowel to a hard, dense, burnished finish. Do not double steel trowel interior slabs on grade having an underslab vapor retarder.

3.4 SCRATCH OR RAKED FINISH

A. Description: Apply to monolithic slab surfaces scheduled to receive adhered and bonded, mortar setting beds for tile and stone paving and other bonded cementitious finish flooring material.

3.5 BROOM FINISH

A. As indicates in Article 1.5, Paragraph D, Sub-paragraph 2 above.

3.6 SITE TOLERANCES

A. Surfaces Scheduled to Receive a Scratch Finish: After placing slabs, plane the surface to a tolerance not exceeding 1/4-inch in 2 feet when tested with a 2 feet straightedge.

1. Slope surfaces uniformly to drains where required.
2. After leveling and before the final set, roughen the surface with stiff brushes, brooms or rakes.

B. All Other Surfaces: Finish to a tolerance of 1/8-inch in 10 feet when measured with a 10-foot straightedge placed anywhere on the surface. Variation from level shall not exceed 1/8-inch overall.

3.7 CONCRETE PROTECTING AND CURING

A. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306. 1 for cold-weather protection and with ACI 301 for hot-weather protection during curing.
B. Begin curing concrete immediately after applying as-cast finish. Cure in compliance with ACI 308.1, by one or a combination of the following methods that will not mottle, discolor, or stain concrete.

3.8 MOISTURE CURING

A. Keep exposed surfaces of cast-in-place architectural concrete continuously moist for not less than 7 days with one of the following curing methods.

1. Water Curing Method:
2. Fog Curing Method:
   a. Immediately after concrete has been brought to a flat surface and the shiny film of moisture disappears, restore it and maintain until final troweling by applying a light film of moisture with an atomizing type fog sprayer.
   b. Use frequent light applications of moisture rather than excessive amounts at any one time. Adjust the amount and frequency of fog spray as required by variable conditions of weather, wind, temperature and humidity.
3. Canvas or Burlap Curing Method: Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.

3.9 SHEET MEMBRANE CURING

A. Promptly after troweling or finishing, and as soon as it can be done without marring finish, cover concrete surfaces with moisture-retaining sheet membrane cover.

1. Lay sheet membrane in widest practicable width, with sides and ends lapped a minimum of 12 inches.
2. Seal laps and seams with pressure-sensitive waterproof tape or adhesive.

B. Cure concrete continuously for a minimum of 14 days. Immediately repair any holes, tears or other damage to sheet membrane during the curing period.

C. Leave sheet membrane in place as temporary protection as long as possible.

3.10 LIQUID MEMBRANE-FORMING COMPOUND CURING

A. Promptly after troweling or finishing, and as soon as it can be accomplished without marring or damaging concrete finish, mist concrete surfaces with water and apply curing compound uniformly in one continuous operation in compliance with its manufacturer instructions.
1. When the curing compound manufacturer recommends a coverage range, either use heavier application rate or consult with Engineer and manufacturer for appropriate coverage rate based upon intended use.
2. Do not exceed manufacturer’s recommended coverage rate.

B. Maintain continuity of coating and repair damage during curing period.
   1. Examine application at regular intervals to verify compound film is intact.
   2. If damaged, moisten the concrete and apply additional compound.
   3. Reccoat areas subjected to heavy rainfall within three hours after initial application.

3.11 REPAIR/RESTORATION
   A. Repair damaged areas to match adjacent areas as approved by the Engineer.
   B. Remove and replace materials that are damaged, have been stained, that do not match adjacent materials or cannot be satisfactorily cleaned or repaired, as determined and directed by the Engineer, at no cost to the Owner.

3.12 PROTECTION
   A. Protect concrete against damage and stains until substantial completion.

3.13 FORMED CONCRETE FINISH SCHEDULE
   A. To be determined.

3.14 CONCRETE FLATWORK FINISH SCHEDULE
   A. To be determined.

END OF SECTION 033500
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Foamed insulation core metal panels (WP-01).
2. Concealed fastener lap seam formed metal panels (WP-02) installed over multi-component framed wall system.
3. Supplementary components and accessories necessary for a complete and weathertight installation.

1.2 REFERENCES

A. Abbreviations and Acronyms:

1. AA: Aluminum Association.
3. AHJ: Authority (Authorities) Having Jurisdiction.
4. AL: Air Leakage.
5. DFT: Dry Film Thickness.
6. HDG: Hot Dip Galvanized.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting:

1. In order to review selected metal panel assemblies required for this Project and to coordinate the Work of this Section with the Work of other trades, arrange for a preinstallation meeting between the Contractor, Engineer, metal panel manufacturer's field representatives, installer and related trades to be held at least 2 weeks prior to the start of work, including ordering selected materials.
2. If more than one trade will be responsible for the Work of this Section, then those trades shall also attend the meeting.
3. Review Contract Documents, metal panel manufacturer-prepared instructions, project conditions, and proposed methods and procedures related to installation.
   a. Identify conditions that would be detrimental to proper installation and protection.
   b. Review special details corner conditions drainage patterns penetrations accessories components similar conditions and
adjacent construction that will impact or otherwise affect metal panel installation.

4. Review substrates to receive metal panel assemblies in order to verify compliance with specified requirements, and with manufacturer's substrate tolerance recommendations and surface preparation requirements, including flatness quality of attachment to structure.

5. Review specified requirements for testing and inspection reports and closeout submittals.

6. Review sequence of installation, finalize construction schedule, and verify availability of materials, personnel, equipment and facilities necessary to make progress and avoid delays.

7. Review temporary protection procedures required to be followed in order to provide protection of stored and installed metal panels both during and after installation.

8. Record significant meeting discussions, agreements and disagreements, including required corrective measures and actions to be taken prior to the start of metal panel installation. No later than 3 calendar days following the meeting, distribute copies of minutes to Engineer, to each party present, and to parties who should have been present.

9. Do not proceed with installation if disagreements resulting from meeting have not been successfully resolved to the satisfaction of the disagreeing parties. Instead, initiate necessary actions to remove impediments to execution of the Work and reconvene meeting at earliest available date to resolve outstanding disagreements.

1.4 SUBMITTALS

A. Product Data: Combine all product data specified below together and submit as one coordinated submittal.

1. Submit a comprehensive list of all proposed metal panel assembly components and accessories necessary for complete installation, along with their manufacturer's product data, typical installation details and other data necessary to demonstrate compliance with specified requirements for each item listed.

2. Along with the other required submittals for items furnished under this Section, combine copies of manufacturer's product data for items furnished under other Sections together with the product data required for the work installed under this Section.

3. Submit sample copies of specified warranties with terms, conditions, exclusions, limitations and time periods for each warranty clearly defined and expressed.

B. Shop Drawings:

1. Submit dimensioned drawings, including elevations and sections showing metal panel layout materials joints profiles edge conditions attachments to other work and finishes

2. Label individual components with manufacturer's product name.
a. Indicate method of field assembly, components, and location and size of each field connection.
b. Distinguish between factory- and field-assembled work.

3. Provide elevation drawings of each surface to be covered with metal panels. Show location of all components, accessories and trim, including joint locations openings and penetrations installed in each surface.

4. Submit project-specific minimum 1-1/2-inch scale dimensioned detail drawings showing profiles, joints, seams, and dimensions, including terminations, penetrations, and interior and exterior corner conditions either not detailed on manufacturer's product data, or indicated on manufacturer's product data, but not in a manner specific to this project. Furnish edge details where specified items abut adjacent items.

5. Indicate method of securely fastening to supporting construction. Show fasteners brackets clips cleats mounting devices and attachments to other work. Label each fastener type with manufacturer's product name and both material indication and finish.

6. Provide pictorial oblique or axonometric projection drawings for conditions too difficult to illustrate as 2-dimensional multi-view orthographic projection drawings. Perspective projections do not meet the requirements for 3-D drawings and will not be reviewed.

7. Coordinate shop drawings with related work specified in other Sections. Indicate and distinguish between the Work of this Sections and work to be installed as part of the Work of other Sections, including adjacent and abutting materials to which the Work of this Section will be attached.

C. Samples:

1. Metal Panels: Submit minimum 12-inch long by actual panel width samples in the specified color and finish.
2. Trim and Closures: Submit minimum 12-inch long samples of each accessory type in the specified color and finish. Include fasteners and other exposed accessories.
3. Exposed Sealants: For each type and color of joint sealant required. Install joint sealants in 1/2-inch-wide joints formed between two 6-inch-long strips of material matching the appearance of wall panels adjacent to joint sealants.
4. Exposed Gaskets: and Other Accessories: Submit minimum 12-inch long samples of each type. Of gasket or accessory.

D. Certificates: Prior to starting the Work of this Section, submit a letter from the metal panel manufacturer, on company letterhead, certifying proposed installer is acceptable to or has been authorized certified licensed trained or otherwise qualified by the metal panel manufacturer, and is qualified to install units required for this Project.

E. Installation Instructions:

1. Submit manufacturer-prepared instructions concerning proper installing protecting and cleaning of metal panel assemblies and surfaces.
2. If manufacturer-prepared instructions are either unavailable or do not apply to project-specific conditions, then consult with manufacturer's technical representative and obtain manufacturer-prepared installation requirements, recommendations or instructions in writing, and promptly distribute copies manufacturer-prepared requirements, recommendations or instructions to Engineer before proceeding with work.

F. Qualification Statements:

1. Installer's Qualifications: Provide a written description of proposed experience, along with a list of at least 5 projects similar in material, design, complexity and extent to this Project and successfully completed within the past 5 years by the proposed metal panel installer.

2. Testing and Inspection Agency Qualifications: Provide a written description of proposed testing and inspection agency's experience, along with a list of at least 5 projects similar in material, design, complexity and extent to this Project and successfully completed in California within the past 5 years for which the proposed testing and inspection agency sampled and tested assemblies similar in design, complexity and extent to this Project.

G. Closeout Submittals: Combine operation and maintenance data and warranty documentation together and submit as one coordinated submittal.

1. Operation and Maintenance Data: Furnish Owner with a copy of metal panel manufacturer's recommendations for maintenance, including care, adjusting, protection, and troubleshooting of metal panel assemblies.
   a. Submit the metal panel manufacturer's recommendations for periodic inspections. Identify common causes of damage along with providing manufacturer-prepared instructions for repair and touchup.
   b. Submit the metal panel manufacturer's recommendations for cleaning and refinishing of metal panels, including precautions against materials and methods that may be detrimental to the durability appearance and performance of installed metal panel assemblies.

2. Warranty Documentation: Submit final copies of specified warranties, with terms, conditions, exclusions, limitations and time periods for each warranty clearly defined and expressed.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each metal panel assembly type used for the Project through one source from a single manufacturer and production run.

B. Qualifications:
1. Manufacturer: Company with a minimum of 10 consecutive years experience in the regular manufacture and production of specified metal panel assemblies required for this Project, whose panel assemblies installed on projects similar in material, design, complexity and extent to this project have resulted in applications with a record of successful in-service performance.

2. Installer: Company with a minimum of 5 consecutive years experience in the installation of selected metal panel assemblies, and whose work on projects similar in material, design, complexity and extent to this Project has resulted in applications with a documented record of successful in-service performance.

C. Regulatory Requirements: Foamed insulation core metal panels with the following fire-test characteristics determined by indicated test standard as applied by UL or other testing and inspection agency acceptable to authorities having jurisdiction.

1. Surface-Burning Characteristics: Provide metal composite wall system panels with the following characteristics when tested per ASTM E 84.
   a. Flame spread index: 25 or less.
   b. Smoke developed index: 450 or less.

2. Fire Performance of Insulated Wall: Class 1 wall panel per ANSI/FM 4880.

3. Room Corner Test: NFPA 286 or UL 1715.

D. Mockups: Before starting the Work of this Section, assemble an integrated mockup in order to review installation techniques, to coordinate the Work of multiple sections, to train the trades involved in the Work, and to demonstrate aesthetic effects, quality of materials, and fabrication and installation (workmanship).

1. Mockup size, configuration and features will be selected by the Engineer.
2. Submit shop drawings of proposed mockup for information.
3. After Engineer's review of mockup shop drawings by the Engineer, assemble Type B mockup (part of the building, aesthetic, and erected after Engineer's review of product submittals) in compliance with Engineer's review comments. Demonstrate materials and techniques proposed for repair of surface blemishes to match adjacent undamaged surfaces where directed by Engineer.
4. Engineer will review mockup to determine if the Work falls within acceptable ranges for the following.
   b. Mottling, sheen, color and texture variation, and evenness of finish.
   c. Integration of the Work of different trades.
   d. Tolerances.
   e. Quality and fabrication and installation (workmanship).
   f. Compliance with specified performance requirements.
5. Make corrections requested by Engineer or remove and replace mockup when corrective work is not acceptable. Repeat mockup until Engineer's approval is obtained.

6. Protect approved mockup, which will be used as an example of the acceptable standard for remaining work, until removal is authorized in writing by Engineer.

1.6 WARRANTY

A. Panel Assembly Warranty:

1. Provide specific protection against problems resulting from defective materials, components, and accessories, patent or latent defects, and incipient or catastrophic failure for at least 2 years after Substantial Completion. Defects include the following.

   a. Structural failures, including rupturing, cracking, or puncturing.
   b. Deterioration of metals and other materials beyond normal weathering.

B. Panel Finish Warranty:

1. Provide specific protection against deterioration of factory-applied finishes for at least 20 years after Substantial Completion. Deterioration includes the following.

   a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
   b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
   c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

C. Remedy: At no cost to the Owner, replace or repair defective or deteriorated work that occurs during the specified warranty periods.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Design is based on products by CENTRIA Architectural Systems. Other acceptable sources of comparable products are limited to one of the following, subject to compliance with the requirements specified below.

1. Metal Sales Manufacturing Corp.
3. Or Approved Substitute.
B. Provide all metal wall panel and panel accessories specified in this section by a single manufacturer.

2.2 FOAMED-INSULATION-CORE METAL PANELS (WP-01)

A. Description:

1. Factory-formed and -assembled metal wall panels fabricated from two metal facing sheets and insulation core foamed in place during fabrication, and with joints between panels designed to form weathertight seals.
2. The following are not permitted:
   a. Laminated panels.
   b. Barrier wall-designed systems.
   c. Systems relying upon field-installed gaskets or wet seals to meet performance requirements.

B. Products: “Formawall Dimension Series” insulated panelized exterior metal wall system, or Approved Substitute.

C. Comply with the Following:

1. Panel Type: Concealed-fastener.
2. Panel Depth: As indicated on the Drawings.
4. Panel Ends: Factory formed trimless ends, tabbed under panel horizontal shelf.
5. Color: Match CENTRIA color 9989, “Platinum”.
6. Core Construction:
   a. Insulation Core: Closed cell, modified polyisocyanurate foam using a non-CFC/HCFC blowing agent, foamed-in-place type, with maximum flame-spread index of 25 and smoke-developed index of 450.
   b. Closed-Cell Content: 90 percent when tested according to ASTM D 2856.
   c. Density: At least 2.7 pounds per cubic foot.
   d. Compressive strength: At least 20 pounds per square inch.


D. Performance Requirements:

1. Cladding System: Meet the following performance requirements when tested in accordance with AAMA 508-07, including a horizontal joint, with an imperfect vapor barrier.
   a. Air Leakage: Maximum permanent AL rating of not more than 0.06 CFM per square foot, when tested in compliance with ASTM E
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283. at a minimum differential static air pressure across the assembly of 6.24 psf.

b. Water Leakage: No water leakage through assembly or joints, when tested in compliance with ASTM E 331 at 15 psf.

2. Panel Performance:

a. Thermal Expansion and Contraction: Provide materials, products, and assemblies engineered to accommodate movement resulting from the following ambient and material surface temperature differential.

1) Design Ambient Temperature Differential (Change): Minimum 120 deg. F.
2) Design Material Surface Temperature Differential (Change): Minimum 180 deg. F.
3) Base engineering calculations on material surface temperatures due both to solar heat gain and to nighttime-sky heat loss.
4) Provide fasteners that resist rotation and withstand shear stress resulting from thermal expansion and contraction.

b. Permanent Deformation: No permanent deformation of any panel exceeding 0.2-percent of clear span, when tested in compliance with ASTM E 330.

1) Test Load at Corner and Parapet Conditions: 30 psf.
2) Test Load Elsewhere: 20 psf.

c. Flatwise Tensile Strength: 30 psi when tested according to ASTM C 297.

d. Humid Aging: Volume increase not greater than 6.0 percent and no delamination or metal corrosion when tested for 7 days at 140 deg F and 100 percent relative humidity according to ASTM D 2126.

e. Heat Aging: Volume increase not greater than 2.0 percent and no delamination, surface blistering, or permanent bowing when tested for 7 days at 200 deg F according to ASTM D 2126.

f. Cold Aging: Volume decrease not more than 1.0 percent and no delamination, surface blistering, or permanent bowing when tested for 7 days at minus 20 deg F according to ASTM D 2126.

g. Fatigue: No evidence of delamination, core cracking, or permanent bowing when tested to a 20-lbf/sq. ft. positive and negative wind load and with deflection of L/180 for 2 million cycles.

h. Autoclave: No delamination when exposed to 2-psi pressure at a temperature of 212 deg F for 2-1/2 hours.

3. Polyisocyanurate Insulation-Core Performance:

a. Density: 2.0 to 2.6 lb/cu. ft. when tested according to ASTM D 1622.

b. Compressive Strength: Minimum 20 psi when tested according to ASTM D 1621.
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c. Shear Strength: 26 psi when tested according to ASTM C 273.


E. Fabrication:

1. General: Fabricate and finish metal wall panels and accessories at the factory to greatest extent possible, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.

2. Fabricate metal wall panels in a manner that eliminates condensation on interior side of panel and with joints between panels designed to form weathertight seals.

3. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of panel.

4. Fabricate metal wall panel joints with factory-installed captive gaskets or separator strips that provide a tight seal and prevent metal-to-metal contact, in a manner that will minimize noise from movements within panel assembly.

5. Sheet Metal Accessories: Fabricate flashing and trim to comply with recommendations in SMACNA's “Architectural Sheet Metal Manual” that apply to the design, dimensions, metal, and other characteristics of item indicated.

a. Form exposed sheet metal accessories that are without excessive oil canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.

b. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.

c. Seams for Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.

d. Sealed Joints: Form nonexpansion but movable joints in metal to accommodate elastomeric sealant to comply with SMACNA standards.

e. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of accessories exposed to view.

f. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal recommended by metal wall panel manufacturer.

1) Size: As recommended by SMACNA's “Architectural Sheet Metal Manual” or metal wall panel manufacturer for application but not less than thickness of metal being secured.
2.3 CONCEALED FASTENER LAP SEAM FORMED METAL PANELS (WP-02)

A. Product: “IW-10A” factory-formed lap-seam formed metal panels, or Approved Substitute.

B. Comply with the Following:

1. Panel Thickness: Minimum 0.0356-inch (20-gage USS) base metal thickness pre-painted steel sheet.
4. Panel coverage: 12 inches.
5. Color: Match CENTRIA color “XL Silver”.

C. Components:

1. Extruded Trim: “Microline Extrusions” or Approved Substitute.

D. Fabrication:

1. General: Fabricate and finish metal wall panels and accessories at the factory to greatest extent possible, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.
2. Fabricate metal wall panels in a manner that eliminates condensation on interior side of panel and with joints between panels designed to form weathertight seals.
3. Fabricate metal wall panel joints with factory-installed captive gaskets or separator strips that provide a tight seal and prevent metal-to-metal contact, in a manner that will minimize noise from movements within panel assembly.
4. Sheet Metal Accessories: Fabricate flashing and trim to comply with recommendations in SMACNA's “Architectural Sheet Metal Manual” that apply to the design, dimensions, metal, and other characteristics of item indicated.

a. Form exposed sheet metal accessories that are without excessive oil canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.

b. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.

c. Seams for Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.

d. Sealed Joints: Form nonexpansion but movable joints in metal to accommodate elastomeric sealant to comply with SMACNA standards.
e. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of accessories exposed to view.

f. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal recommended by metal wall panel manufacturer.

1) Size: As recommended by SMACNA’s "Architectural Sheet Metal Manual" or metal wall panel manufacturer for application but not less than thickness of metal being secured.

2.4 ACCESSORIES

A. Closures: Provide closures at eaves and rakes, fabricated of same metal as metal panels.

B. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.

C. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch-thick, flexible closure strips; cut or premolded to match metal wall panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.

D. Mitered Corners: Provide trimless structurally-bonded corner to match exterior profile panel in shape, material and finish with no exposed fasteners.

E. Closures: Provide metal and foam closures fabricated from the same material, gauge and finish as exterior wall panel.

F. Fasteners: Provide minimum 0.242-inch shank diameter (No. 14 UTS) hex washer-head austenitic stainless-steel self-drilling tapping screws complying with ASTM A 276 Type 304, coated to match exposed panel surface color, with minimum 5/8-inch diameter bonded polychloroprene (Neoprene) and stainless steel washers.

G. Clips: Manufacturer's standard one piece, formed from aluminum-zinc alloy-coated steel or stainless steel.

H. Gaskets: Extruded, dry seal silicone.

I. Sealant: Manufacturer's standard silicone.

J. Edge Members: Extruded aluminum, not less than 0.063-inch wall thickness.

K. Flashing and Trim: Formed from 0.018-inch minimum thickness, zinc-coated (galvanized) steel sheet or aluminum-zinc alloy-coated steel sheet prepainted with coil coating. Provide flashing and trim as required to seal against weather.
and to provide finished appearance. Locations include, but are not limited to, bases, drips, sills, jambs, corners, endwalls, framed openings, rakes, fasciae, parapet caps, soffits, reveals, and fillers. Finish flashing and trim with same finish system as adjacent metal wall panels.

L. Support Framing Members: Hot- or cold-rolled steel members of required size and shape, conforming to the following.

1. Steel plates: ASTM A 283, Grade C.
4. Aluminum extrusion panel retention members, clips, angles or panel hangers: Alloy, temper and shape required to meet or exceed performance criteria specified.

M. Clips, Pins and Fasteners: Concealed, non-corrosive, non-deteriorating clips pins and fasteners of quantity and type recommended by panel manufacturer that are compatible with panel face.

1. Secure clips in the manufacturer's facility to the greatest degree possible.
2. Pop rivet attachment of clips and accessories will not be accepted.
3. Do not overdrive fasteners.

N. Gaskets and Sealants used in Panel Assembly: As specified and as recommended by the panel manufacturer to meet or exceed performance criteria. Color to be selected by Engineer from manufacturer's standard palette.

O. Sound-deadening compound: Design is based on “Model KDC-E-162” semi-liquid sprayable paste by Kinetics Noise Control or Approved Substitute.

2.5 FINISHES

A. Provide all metal panels with shop-applied fluoropolymer finish as specified, or equal by the panel manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and surfaces to receive coatings.

B. Inspect framing that will support metal wall panels to determine if support components are installed as indicated on approved shop drawings. Confirm presence of acceptable framing members at recommended spacing to match installation requirements of metal wall panels.

C. Verify that window, door, louver and other penetrations match layout on shop drawings.
D. Confirm that air/moisture barrier work has been completed, inspected, and tested as required.

E. Correct conditions detrimental to the proper and timely completion of this work before proceeding with installation.

3.2 METAL PANEL INSTALLATION

A. General: Install wall panels according to manufacturer's written instructions in orientation, sizes, and locations indicated on Drawings. Install panels perpendicular to girts and subgirts unless otherwise indicated. Anchor panels and other components of the Work securely in place, with provisions for thermal and structural movement.

1. Apply elastomeric sealant continuously between metal base channel (sill angle) and concrete, and elsewhere as indicated or, if not indicated, as necessary for waterproofing.
2. Provide weathertight escutcheons for pipe and conduit penetrating exterior walls.

B. Joint Sealers: Install gaskets, joint fillers, and sealants where indicated and where required for weathertight performance of metal wall plate panel assemblies. Provide types of gaskets, fillers, and sealants indicated or, if not indicated, types recommended by panel manufacturer.

1. Seal metal panel end laps with double beads of sealant, full width of panel. Seal side joints where recommended by panel manufacturer.
2. Prepare joints and apply sealants to comply with requirements in Section 079213 “Elastomeric Joint Sealants.”

3.3 LAP SEAM METAL WALL PANEL INSTALLATION

A. Fasten metal wall panels to supports with fasteners at each lapped joint at location and spacing recommended by manufacturer.

1. Lap ribbed or fluted sheets one full rib corrugation. Apply panels and associated items for neat and weathertight enclosure. Avoid “panel creep” or application not true to line.
2. Provide metal-backed washers under heads of exposed fasteners bearing on weather side of metal wall panels.
3. Locate and space exposed fasteners in uniform vertical and horizontal alignment. Use proper tools to obtain controlled uniform compression for positive seal without rupture of washer.
4. Install screw fasteners with power tools having controlled torque adjusted to compress washer tightly without damage to washer, screw threads, or panels. Install screws in predrilled holes.
5. Provide sealant tape at lapped joints of metal wall panels and between panels and protruding equipment, vents, and accessories.
6. Apply a continuous ribbon of sealant tape to weather-side surface of fastenings on end laps; on side laps of nesting-type panels; on side laps of corrugated nesting-type, ribbed, or fluted panels; and elsewhere as needed to make panels weathertight.

7. At panel splices, nest panels with minimum 6-inch end lap, sealed with butyl-rubber sealant and fastened together by interlocking clamping plates.

B. Zee Clips: Provide Zee clips of size indicated or, if not indicated, as required to act as standoff from subgirts for thickness of insulation indicated. Attach to subgirts with fasteners.

3.4 INSULATED-CORE METAL WALL PANEL INSTALLATION

A. General: Apply continuous ribbon of sealant to panel joint on concealed side of insulated-core metal wall panels as vapor seal; apply sealant to panel joint on exposed side of panels for weather seal.

1. Fasten insulated-core metal wall panels to supports with fasteners at each lapped joint at location and spacing and with fasteners recommended by manufacturer.

2. Lap ribbed or fluted sheets one full rib corrugation. Apply panels and associated items for neat and weathertight enclosure. Avoid “panel creep” or application not true to line.

3. Provide metal-backed washers under heads of exposed fasteners on weather side of insulated metal wall panels.

4. Locate and space exposed fasteners in uniform vertical and horizontal alignment. Use proper tools to obtain controlled uniform compression for positive seal without rupture of washer.

5. Provide sealant tape at lapped joints of insulated metal wall panels and between panels and protruding equipment, vents, and accessories.

6. Apply a continuous ribbon of sealant tape to panel side laps and elsewhere as needed to make panels weathertight.

B. Foamed-Insulation-Core Metal Wall Panels: Fasten metal wall panels to supports with concealed clips at each joint at location and spacing and with fasteners recommended by manufacturer. Fully engage tongue and groove of adjacent panels.

1. Install clips to supports with self-tapping fasteners.

END OF SECTION 074213
SECTION 079213 – ELASTOMERIC JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sealants where necessary, indicated or required for to make the building airtight and weatherproof.
2. Supplementary components, accessories and details work necessary for a complete installation.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Provide joint sealants that establish and maintain continuous watertight and airtight joint seals without staining or deteriorating joint substrates.

B. For applications where sealants are applied to porous substrates, provide products that have undergone testing conforming to ASTM C 1248 and have not stained porous joint substrates indicated for the Project.

1.3 SUBMITTALS

A. Product Data: For each joint-sealant product indicated.

B. Samples for Initial Selection: Manufacturer's color charts consisting of strips of cured sealants showing the full range of colors available for each product exposed to view.

C. Samples for Verification: For each type and color of joint sealant required, provide Samples with joint sealants in 1/2-inch-wide joints formed between two 6-inch-long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.

D. Product Certificates: For each type of joint sealant and accessory, signed by product manufacturer.

E. Compatibility and Adhesion Test Reports: From sealant manufacturer, indicating the following:

1. Materials forming joint substrates and joint-sealant backings have been tested for compatibility and adhesion with joint sealants.
2. Interpretation of test results and written recommendations for primers and substrate preparation needed for adhesion.
F. Field Test Report Log: For each elastomeric sealant application.

G. Warranty Documentation: Submit final copies of specified warranties, with terms, conditions, exclusions, limitations and time periods for each warranty clearly defined and expressed.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of joint sealant through one source from a single manufacturer.

B. Preconstruction Compatibility and Adhesion Testing: Submit to joint-sealant manufacturers, for testing indicated below, samples of materials that will contact or affect joint sealants.

1. Use ASTM C 1087 to determine whether priming and other specific joint preparation techniques are required to obtain rapid, optimum adhesion of joint sealants to joint substrates.

2. Submit not fewer than 8 pieces of each type of material, including joint substrates, shims, joint-sealant backings, secondary seals, and miscellaneous materials.

3. Allow sufficient time in the construction schedule for testing and analyzing results to prevent delaying the Work.

4. For materials failing tests, obtain joint-sealant manufacturer’s written instructions for corrective measures including use of specially formulated primers.

C. Preconstruction Field-Adhesion Testing: Before installing elastomeric sealants, field test their adhesion to Project joint substrates as follows:

1. Locate test joints where indicated on Project or, if not indicated, as directed by Engineer.

2. Conduct field tests for each application indicated below:

   a. Each type of elastomeric sealant and joint substrate indicated.
   b. Each type of non-elastomeric sealant and joint substrate indicated.

3. Notify Engineer seven days in advance of dates and times when test joints will be erected.

4. Arrange for tests to take place with joint-sealant manufacturer’s technical representative present.


   b. For joints with dissimilar substrates, verify adhesion to each substrate separately; extend cut along one side, verifying adhesion to opposite side. Repeat procedure for opposite side.
5. Report whether sealant in joint connected to pulled-out portion failed to adhere to joint substrates or tore cohesively.
   a. Include data on pull distance used to test each type of product and joint substrate.
   b. For sealants that fail adhesively, retest until satisfactory adhesion is obtained.

6. Evaluation of Preconstruction Field-Adhesion-Test Results: Sealants not evidencing adhesive failure from testing, in absence of other indications of noncompliance with requirements, will be considered satisfactory. Do not use sealants that fail to adhere to joint substrates during testing.

1.5 WARRANTY

A. Special Installer's Warranty: Installer's standard form in which Installer agrees to repair or replace elastomeric joint sealants that do not comply with performance and other requirements specified in this Section within 2 years from date of Substantial Completion.

B. Special Manufacturer's Warranty: Manufacturer's standard form in which elastomeric sealant manufacturer agrees to furnish elastomeric joint sealants to repair or replace those that do not comply with performance and other requirements specified in this Section within 10 years from date of Substantial Completion.

C. Special warranties specified in this Article exclude deterioration or failure of elastomeric joint sealants from the following.

   1. Movement of the structure resulting in stresses on the sealant exceeding sealant manufacturer's written specifications for sealant elongation and compression caused by structural settlement or errors attributable to design or construction.
   2. Disintegration of joint substrates from natural causes exceeding design specifications.
   3. Mechanical damage caused by individuals, tools, or other outside agents.
   4. Changes in sealant appearance caused by accumulation of dirt or other atmospheric contaminants.

PART 2 - PRODUCTS

2.1 TRAFFIC JOINT SEALANTS

A. High Modulus Single-Component Traffic Sealant: Installed for weathersealing interior and exterior walkways, plazas, decks, parking garages, and similar horizontal application joints subject to pedestrian or vehicular traffic.
1. Description: Urethane sealant complying with ASTM C 920 requirements for Type M, Grade P, Class 25, Use T, M or 0 sealant, as applicable.

2. Product: Basis of design is "Sikaflex-1C SL" by Sika Corp. Other acceptable products include the following.
   b. "Urexpan NR-201" by Pecora Corp.
   c. Or Approved Substitute.

2.2 EXTERIOR POINT SEALANTS

A. Ultra-Low Modulus Single-Component Sealant: Installed for weathersealing joints in metal-framed storefronts and curtain walls, for perimeter sealing of entrance doors and windows, and for weathersealing exterior other building joints subject to extreme or dynamic movement.

1. Description: Neutral-curing silicone sealant complying with ASTM C 920 requirements for Type S, Grade NS, Class 100/50, Use NT, A or 0 sealant, as applicable.

2. Products: Basis of design is “790” by Dow Corning Corp. Other acceptable products include the following.
   a. “SikaSil-C 990” by Sika Corp.
   b. “Spectrem 1” by Tremco, Inc.
   c. Or Approved Substitute.

3. Color: To be selected by the Engineer.


1. Description: Neutral-curing silicone sealant complying with ASTM C 920 requirements for Type S, Grade NS, Class 50, Use NT, M, G, A or 0 sealant, as applicable.

2. Products: Basis of design is “795” by Dow Corning Corp. Other acceptable products include the following.
   a. “SikaSil-C 995” by Sika Corp.
   b. “Spectrem 3” by Tremco, Inc.
   c. Or Approved Substitute.

3. Color: To be selected by the Engineer.

C. Low Modulus Single-Component Sealant for Porous Surfaces: Installed for weathersealing exterior building joints in sensitive porous stone and metal panel substrates requiring reduced residue rundown and reduced substrate staining.
1. **Description:** Neutral-curing silicone sealant complying with ASTM C 920 for Type S, Grade NS, Class 50, Use NT, M, G, A or O sealant, as applicable.

2. **Products:** Provide “756 SMS” by Dow Corning Corp. or Approved Substitute.

3. **Color:** To be selected by the Engineer.

**D. Medium Modulus Single-Component Sealant:** Installed for weathersealing perimeter door and punched window openings and similar building component joints.

1. **Description:** Neutral-curing silicone sealant complying with ASTM C 920 requirements for Type S, Grade NS, Class 25, Use NT, G, A, M or 0 sealant, as applicable.

2. **Products:** Basis of design is “Contractor’s Weatherproofing Sealant” by Dow Corning Corp. Other acceptable products include the following.

   a. “Pecora 895NST” by Pecora Corp.
   b. “Spectrem 2” by Tremco, Inc.
   c. Or Approved Substitute.

3. **Color:** To be selected by the Engineer.

### 2.3 INTERIOR JOINT SEALANTS

**A. Specialty Silicone Elastomeric Joint Sealants:** Single-component damp location sealant installed for sealing interior joints, other than floor joints, that are located in toilet rooms, bathrooms, and similar damp, wet and semi-wet locations.

1. **Description:** White or clear medium or high modulus mildew-resistant silicone sealant complying with ASTM C 920 requirements for Type S, Grade NS, Class 25, Use NT, A or O sealant, as applicable.

2. **Products:** Basis of design is “786” by Dow Corning Corp. Other acceptable products include the following.

   a. “Pecora 898” by Pecora Corp.
   b. “Tremsil 200” by Tremco, Inc.
   c. Or Approved Substitute.

**B. Acrylic Latex Elastomeric Joint Sealants:** General purpose interior sealant installed at interior vertical and overhead substrate joints.

1. **Description:** Siliconized acrylic-latex sealant complying with ASTM C 834 requirements for Type OP, Grade NF classification, as required.

2. **Products:** Provide one of the following.

   b. “AC-20+Silicone” by Pecora Corp.
   c. “Tremflex 834” by Tremco, Inc.
2.4 JOINT SEALANT BACKINGS

A. Bi-Cellular Foam Joint Backings:

1. Description: Extruded polyethylene foam cylindrical sealant backings complying with ASTM C 1330, Type B.

2. Products: Provide one of the following.

3. “Sof Rod” or “Dual Rod” by Nomaco, Inc. or Approved Substitute. Comply with the following:

   a. Water Absorption: Between 0.03 and 0.10 grams per cubic centiliter when tested in compliance with ASTM C 1016, Procedure B.
   b. Density: Between 24 and 48 kilograms per cubic meter when tested in compliance with ASTM D 1622.
   c. Outgassing: Less than 1 bubble when tested in compliance with ASTM D 1253.
   d. Compression Recovery: Greater than 90 percent when tested in compliance with ASTM D 5249.
   e. Compression Deflection: Greater than 20.5 percent when tested in compliance with ASTM D 5249.
   f. Tensile Strength: Greater than 200 kPa when tested in compliance with ASTM D 1623.

B. Tape Joint Backings:

1. Description: Self-adhering polyethylene or other plastic tape

2.5 FIELD QUALITY CONTROL

A. Field-Adhesion Testing: Field test joint-sealant adhesion to joint substrates as follows:

1. Extent of Testing: Test completed elastomeric sealant joints as follows:

   a. Perform 10 tests for the first 1000 feet of joint length for each type of elastomeric sealant and joint substrate.
   b. Perform 1 test for each 1000 feet of joint length thereafter or 1 test per each floor per elevation.


   a. For joints with dissimilar substrates, verify adhesion to each substrate separately; do this by extending cut along one side,
verifying adhesion to opposite side. Repeat procedure for opposite side.

3. Inspect joints for complete fill, for absence of voids, and for joint configuration complying with specified requirements. Record results in a field-adhesion-test log.

4. Inspect tested joints and report on the following:
   a. Whether sealants in joints connected to pulled-out portion failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each type of product and joint substrate. Compare these results to determine if adhesion passes sealant manufacturer’s field-adhesion hand-pull test criteria.
   b. Whether sealants filled joint cavities and are free of voids.
   c. Whether sealant dimensions and configurations comply with specified requirements.

5. Record test results in a field-adhesion-test log. Include dates when sealants were installed, names of persons who installed sealants, test dates, test locations, whether joints were primed, adhesion results and percent elongations, sealant fill, sealant configuration, and sealant dimensions.

6. Repair sealants pulled from test area by applying new sealants following same procedures used originally to seal joints. Ensure that original sealant surfaces are clean and that new sealant contacts original sealant.

B. Evaluation of Field Test Results: Sealants not evidencing adhesive failure from testing or noncompliance with other indicated requirements will be considered satisfactory.

   1. Remove sealants that fail to adhere to joint substrates during testing or to comply with other requirements.
   2. Retest failed applications until test results prove sealants comply with indicated requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

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

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer’s written instructions and the following requirements:

1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
2. Clean porous joint substrate surfaces by brushing, grinding, blast cleaning, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining after cleaning operations above by vacuuming or blowing out joints with oil-free compressed air. Porous joint substrates include the following:
   a. Concrete.
   b. Masonry.
   c. Stone.

3. Remove laitance and form-release agents from concrete.

B. Joint Priming: Prime joint substrates, where recommended by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer’s written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

C. Masking Tape: Use masking tape where required to prevent contact of sealant with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.3 INSTALLATION OF JOINT SEALANTS

A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.

B. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

C. Install sealant backings of type indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
1. Do not leave gaps between ends of sealant backings.
2. Do not stretch, twist, puncture, or tear sealant backings.
3. Remove absorbent sealant backings that have become wet before sealant application and replace them with dry materials.

D. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.

E. Install sealants using proven techniques that comply with the following and at the same time backings are installed:
   1. Place sealants so they directly contact and fully wet joint substrates.
   2. Completely fill recesses in each joint configuration.
   3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

F. Tooling of Non-sag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants according to requirements specified below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.
   1. Remove excess sealant from surfaces adjacent to joints.
   2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.
   3. Provide concave joint configuration per Figure SA in ASTM C 1193, unless otherwise indicated.
      a. Provide flush joint configuration where indicated per Figure SB in ASTM C 1193.
      b. Provide recessed joint configuration of recessed depth and at locations indicated per Figure SC in ASTM C 1193.
   4. Use masking tape to protect surfaces adjacent to recessed tooled joints.

3.4 FIELD QUALITY CONTROL

A. Field-Adhesion Testing: Field test joint-sealant adhesion to joint substrates as follows:
   1. Extent of Testing: Test completed elastomeric sealant joints as follows:
      a. Perform 10 tests for the first 1000 feet of joint length for each type of elastomeric sealant and joint substrate.
      b. Perform 1 test for each 1000 feet of joint length thereafter or 1 test per each floor per elevation.
EMERGENCY GENERATOR AND DATA CENTER HVAC UPGRADES

3. Inspect joints for complete fill, for absence of voids, and for joint configuration complying with specified requirements. Record results in a field-adhesion-test log.

4. Inspect tested joints and report on the following:

   a. Whether sealants in joints connected to pulled-out portion failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each type of product and joint substrate. Compare these results to determine if adhesion passes sealant manufacturer’s field-adhesion hand-pull test criteria.
   
   b. Whether sealants filled joint cavities and are free of voids.
   
   c. Whether sealant dimensions and configurations comply with specified requirements.

5. Record test results in a field-adhesion-test log. Include dates when sealants were installed, names of persons who installed sealants, test dates, test locations, whether joints were primed, adhesion results and percent elongations, sealant fill, sealant configuration, and sealant dimensions.

6. Repair sealants pulled from test area by applying new sealants following same procedures used originally to seal joints. Ensure that original sealant surfaces are clean and that new sealant contacts original sealant.

B. Evaluation of Field Test Results: Sealants not evidencing adhesive failure from testing or noncompliance with other indicated requirements will be considered satisfactory.

1. Remove sealants that fail to adhere to joint substrates during testing or to comply with other requirements.

2. Retest failed applications until test results prove sealants comply with indicated requirements.

3.5 CLEANING

A. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.6 PROTECTION

A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or
deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from original work.

END OF SECTION 079213
SECTION 210500 – COMMON WORK RESULTS FOR FIRE SUPPRESSION

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Provide all labor, materials, equipment, tools, services and miscellaneous and incidental work to complete the design engineering, and installation of a complete wet pipe sprinkler system throughout the building and Type II standpipe where shown, in accordance with this specification and NFPA 13. Sprinkler protection design shall be based on street main pressure. The sprinkler system hydraulic design point shall fall ten percent below the available supply curve.

B. The following documents, including others referenced therein, form part of this Section to the extent designated herein.

C. American Society of Mechanical Engineers (ASME).

D. American Welding Society (AWS).

E. The latest Structural Welding Code — Steel.

F. Factory Mutual System (FM).

G. Federal Standards (FED STD).

H. FED-STD- 595B Colors Used in Government Procurement.

I. National Fire Protection Association (NFPA).

J. Installation of Sprinkler Systems.


L. California Building Code (CBC) 2013 "Installation of Automatic Sprinkler Systems".

1.2 SUBMITTALS

A. See Division 1 for submittal procedures.

B. Approval Required

1. Design/Fabricator drawings: Before fabrication, submit design, fabrication and installation drawings of the sprinkler systems. Prepare drawings under supervision of, and have submittal stamped by a licensed professional fire protection engineer.
2. The fire sprinkler system shall be DSA “Deferred Approval”.

C. Record drawings: Submit drawings of sprinkler systems as installed.

D. NFPA test certificate: Submit completed Contractor’s F1aterial and Test Certificate in accordance with NFPA 13.

E. Submit evidence of current California C-16 Contractor’s license and list of comparable installations required by Section 1.03 herein.

F. Submit multiple copies of catalog data sheets for all materials per Section 013300 “Submittal Procedures.” Submittals shall include, but not be limited to, the following:
   1. Sprinkler heads and accessories.
   2. Pipe and fittings.
   3. Valves.
   5. Alarm flow switches.
   6. Hangers and supports.
   7. Fire department connections.
   8. Post indicator valves.
   9. Valve supervisory switches.
  11. Identification signs.
  12. Sprinkler head cabinets.

G. Submit shop drawings per Section 013300 “Submittal Procedures.”
   1. Detailed working drawings and hydraulic calculations shall be prepared and submitted for review before fabrication of the project. Working drawings shall be submitted in complete sets (partial submission will not be acceptable) and shall bear the Contractor’s license stamp, identity of the system designer and computer program used in the calculation of hydraulic information.
   2. Fire Marshal approval of submittals is for permission to proceed and does not authorize design, products or installation not conforming to referenced codes and standards and this specification.
   3. Upon completion of the work, the contractor shall provide reproducible As-Built Drawings to the Owner’s Representative. Final approvals are subject to receipt of acceptable As-Built Drawings.
   4. California State Fire Marshal (CSFM) listing numbers (alarm and supervisory devices).

H. Submittals having any content which is incomplete or unclear will be returned without review.

I. Discharge patterns and application data shall be included in submittals for sidewall, water curtain, and similar special purpose sprinklers.
J. Operating instructions: Provide instruction charts describing operation and proper maintenance of system.

1.3 COORDINATION WITH OTHER TRADES

A. The Contractor shall coordinate work among the trades to avoid any interference with the effectiveness of the fire protection system. Shop drawings shall include elevations of equipment and piping for other trades to assure coordination. The fire protection system shall be coordinated with other trades to assure that conflicts will not arise with structural, mechanical, electrical or architectural features of the building. Any changes required by field coordination, shall be provided and installed at no cost to the Owner.

B. The Contractor shall be specifically directed to coordinate with the fire sprinkler and alarm trades to ensure full awareness of the location of all control valves, flow switches, tamper switches, and alarm and signal switches.

1.4 SYSTEM DESCRIPTION

A. Design the sprinkler systems in accordance with NFPA 13 for ordinary hazard group 1 occupancy classification.

B. System shall include a 6-inch alarm check valve, supplied with standard trim, including retard chamber, fire department connection, flow alarm pressure switch, system main drain valve assembly, water motor alarm gong and electrical connections.

C. Components of the system, if not designated in this Section and the Drawings by manufacturer’s name and model/figure number, shall be current products and will be UL listed in the Fire Protection Equipment Directory or Fire Resistance Directory, or FM approved in the Approval Guide for their intended use.

1.5 QUALITY ASSURANCE

A. Product Qualification: See Division 1 for additional requirements related to product qualification and Contractor/Supplier qualifications.

B. Deliverable Documentation: The following documents and records, required by this Section, shall be delivered in accordance with Owner request.

PART 2 - PRODUCTS

2.1 SUBSTITUTES

A. See Division 1 for substitution.
2.2 MATERIALS

A. Piping

1. Pipe and fittings: Meet the requirements of NFPA 13. Piping shall be schedule 40 steel, and with threaded or grooved type (rubber gasketed) fittings. Rubber gasketed fittings for use with plain end pipe shall not be used.

2. Flexible couplings: Bolted sleeve type for use with grooved-end pipe, with rubber rings for sealing.

B. Reducers: One piece concentric threaded reducers, reducing tees for straight run reduction in pipe sizes or grooved type, rubber gasketed reducing couplings. Hexagonal or face busings shall not be used.

C. Identification Labels: Approximately 2-1/4 by 14 inches, bearing the words "FIRE PROTECTION WATER", and a direction arrow approximately 2-1/4 by 7 inches. Labels shall have adhesive backing and installed per California Fire Code.

D. Expansion Anchors.

1. For concrete: Wedge type anchors: Hilti Fastening Systems" Kwik-Bolt II," or ITW-Ramset" Trubolt Wedge Anchor."

2. For filled concrete blocks: Sleeve type anchors; Hilti Fastening Systems “Hot -Hugger,” or ITW-Ramset “Dynabolt Sleeve Anchor.” If open cells are contacted, use toggle bolts.

3. Ceiling hangers at hi-volume ceiling (library) “Epic” metal deck hanging system. ER3.5 “Wedge Nut” hanging devices shall be installable and reloadable along the length of the interior ribs of the ER3.SA Acoustical Roof Deck units. Manufacturer’s product data shall be consulted for minimum spacing, load capacities and proper installation procedure of the ER3. 5 “Wedge Nut” hanging devices.

E. Signs: Provide permanent “CAUTION” signs worded in accordance with NFPA 13.

F. Hydraulic design information sign: Provide a permanently marked, weatherproof metal or plastic sign, with corrosion-resistant attachments, containing information required by NFPA 13.

G. Escutcheons — Primed, steel.

2.3 EQUIPMENT


B. Switches
1. Flow alarm pressure switch for installation on wet pipe sprinkler system retard chamber: Pressure operated having built-in adjustable time retard feature which may be set from 0 seconds to 1 minute or more. Retard feature shall recycle instantly and automatically, and have no build-up. Potter Electric Switch # WFSRC.

2. Flow switches installed directly on sprinkler system piping for fire zone or alarm annunciation shall be flexible vane type, with normally open contacts and instantaneous recycling retard adjustable 15 to 60 seconds.

3. Provide position supervisory switches to supervise sprinkler system control valves. Switches shall be tamperproof, alarms when cover is removed, and alarm during first 2 revolutions of valve hand wheel in closing direction. Switches shall be SPDT, 120 V ac, rated for pilot duty and provided with suitable mounting hardware.

C. Automatic Sprinklers: Nominal */z-inch diameter orifices, rated for ordinary temperature classification, unless other temperature ratings are required by NFPA 13. For Computer Lab sprinklers shall be rated for 200 deg F. The sprinklers shall be recessed automatic type. Reliable Model G with chrome finish.

1. Ceiling Mounted: Pendant type with natural chrome finish and adjustable chrome finish metal escutcheons.

2. Exposed Piping: Upright except where limited space requires pendant; natural brass finish.

3. Ceilings below 10'-0": Provide recessed type heads at all locations.

D. Sprinkler Head Guards: Formed wire or forged steel, suitable for use with upright or pendent sprinklers which can be attached or removed without disturbing sprinkler head, where heads are subject to damage or as directed by the Engineer.

E. Sprinkler Cabinet: Provide with required number of sprinkler heads of ratings and types installed, sprinkler wrench, and mount on wall in the fire sprinkler riser room.

F. Fire Department Connection: Polished chrome finish and furnished with self-closing double clapper, plugs and chains, automatic balldrip valve, and escutcheon plate. Connection shall be 4-inch NPT by 2-1/2-inch hose thread by 1-1/2-inch hose thread. Use Potter-Roemer Figure 5021 for vertical installation.

G. Alarm Check valve: 6-inch supplied with standard trim, including retard chamber. Grinnell Figure F2001 Alarm Valve with figure F211 Retard Chamber, Trim Type A.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Install sprinkler systems in accordance with NFPA 13 for ordinary hazard occupancy classification.

B. Coordinate requirements for interruption of existing services and Fire Department stand-by with the Construction Manager.

C. Protect piping from damage by earthquake by proper clearance around penetration holes, flexible couplings, and sway bracing, in accordance with NFPA 13.

D. Sealing Floor and Wall Penetrations

1. Nonfire Rated.
   a. Cut minimum size hole for pipe passing through gypsum board walls. Seal both sides with polysulfide sealant.
   b. Pack pipe penetrations through concrete floors and walls with fiberglass or mineral wool packing and seal both sides with minimum 1-inch thick polysulfide sealant.
   c. Seal pipe penetrations through concrete block walls both sides to thickness of web with polysulfide sealant. Provide fiberglass or mineral wool packing as required to prevent filling void.

2. Fire Rated
   a. Cut minimum size hole for pipe passing through gypsum board walls. Seal both sides with fire rated sealant.
   b. Seal sprinkler pipe penetrations through concrete floors and walls, and filled concrete block walls with sealant to provide a 2 or 3 hour fire resistance rating in accordance with manufacturer’s test data.
   c. Seal pipe penetrations through nonfilled concrete block walls with sealant in accordance with manufacturer’s test data.

E. Pipe Escutcheons: Install on sides of wall penetrations exposed to view.

F. Repair damaged surfaces. Refinish repaired or defaced surfaces to match adjacent undisturbed areas.

G. Terminate exterior discharge, inspectors test, and auxiliary drain lines with 45 degree elbows, turned down, and extending no more than 4” from wall.

H. Provide suitable splash-pads, at exterior discharge locations, on other than paved surfaces.

I. Install sprinkler head guards where subject to mechanical damage from low elevation or exposure to normal building activities.
J. Paint system piping exposed to view, with 1 coat of zinc chromate primer and 1 coat of semigloss enamel. Finish color shall be red (No. 21105) shown in FED STD 595.

K. Welding

1. Limit welding to fabrication of supports or braces, if necessary. No other on site welding will be permitted, except as specified in this Section or on the Drawings.
2. Perform welding of sprinkler system piping in accordance with NFPA 13. Welding acceptance criteria shall be in accordance with ASME B31.1, Paragraph 136.4.2.
3. Perform welding of steel structural elements in accordance with AWS D1.
   1. Perform visual weld examination in accordance with AWS D1.1 Paragraph 6.5.5.
4. Do not perform welding or flame cutting on or within building.
5. Perform dye penetrant weld examination on cover pass of tie-in welds, not to be hydrostatically tested, in accordance with ASME B31.1 Paragraph 136.4.

L. Hangers and Supports

1. Hang, support and brace sprinkler system piping from building structural steel members, concrete surfaces, or to metal supports attached to building structure or concrete surfaces in accordance with NFPA 13.
2. Use clamping devices when attaching to structural steel. When clamping is impossible, obtain written authority to weld, punch, drill or cut structural steel members to provide attachment.
3. When required, deliver to the Construction Manager detailed mathematical analysis, by registered professional engineer, of structural integrity where questionable alteration of building structural components are proposed. Analysis may also be required where obvious deformations of structural members are caused by hanging sprinkler piping.

M. Identification Labels

1. Install labels after painting is completed.
2. Locate labels on pipe where they can be easily read. Place labels on bottom quadrant of overhead pipe and top quadrant of pipe lower than eye level.
3. Identify only feed mains, cross mains, and risers 3-inch nominal diameter and larger.
4. Locate line identification at intervals of approximately 40 feet on unobstructed runs, and on each side of partitions and floors.

N. Signs

1. Install "CAUTION" signs at control, drain, test, and alarm valves.
2. Install the hydraulic design information sign, placed in accordance with NFPA 13.
3. Electrical Connections — To be completed per 2013 CEC.
3.2 FIELD QUALITY

A. General

1. Furnish equipment and instruments required to perform flushing and testing operations described below.
2. Conduct flushing and testing operations while witnessed by the Inspector of Record. Manager.
3. Remove and replace pieces of apparatus, material, or work which falls in flushing or testing operations and retest.
4. Repair damage resulting from flushing or testing to satisfaction of the Construction Manager.

B. Flushing: Flush sprinkler system piping as described below.

1. Flush sprinkler piping by feeding water into the system through the alarm valve in accordance with NFPA 13.
2. Discharge flushing water from end of cross mains.
3. Discharge flushing water to point designated by the Construction Manager. Flushing shall continue until effluent runs clear and free of foreign matter.
4. Provide documented evidence that flushing has been accomplished in accordance with this Section. Deliver to the Construction Manager before testing.

C. Hydrostatic Testing

1. Hydrostatically test the sprinkler system in accordance with NFPA 13.
2. Use a hydrostatic test pressure of 200 lb/in minimum.
3. Leaks in piping will not be acceptable.

D. Backflow prevention assembly test: Testing shall be at the time of installation, by a State of California, Department of Health Certified Backflow Assembly Tester.

E. Provide two NFPA certificates to the owner, local fire official, and DSA.

END OF SECTION 210500
SECTION 220500 - COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
7. Grout.
8. Plumbing demolition.
9. Equipment installation requirements common to equipment sections.
10. Painting and finishing.
11. Concrete bases.
12. Supports and anchorages.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.
E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

B. Welding certificates.

1.5 QUALITY ASSURANCE

A. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 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.

1.7 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
C. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

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 manufacturers specified.

2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 Piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 22 Piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.

   b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

H. Solvent Cements for Joining Plastic Piping:
   1. ABS Piping: ASTM D 2235.
   2. CPVC Piping: ASTM F 493.
   3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
   4. PVC to ABS Piping Transition: ASTM D 3138.

I. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.4 TRANSITION FITTINGS

A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
   1. Manufacturers:
      b. Dresser Industries, Inc.; DMD Div.
      c. Ford Meter Box Company, Incorporated (The); Pipe Products Div.
      d. JCM Industries.
      e. Smith-Blair, Inc.
      f. Viking Johnson.
      g. Or Approved Substitute.
   2. Underground Piping NPS 1-1/2 and Smaller: Manufactured fitting or coupling.
   4. Aboveground Pressure Piping: Pipe fitting.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.
C. **Dielectric Unions:** Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

1. Manufacturers:
   a. Capitol Manufacturing Co.
   b. Central Plastics Company.
   c. Eclipse, Inc.
   d. Epco Sales, Inc.
   g. Zurn Industries, Inc.; Wilkins Div.
   h. Or Approved Substitute.

D. **Dielectric Flanges:** Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

1. Manufacturers:
   a. Capitol Manufacturing Co.
   b. Central Plastics Company.
   c. Epco Sales, Inc.
   e. Or Approved Substitute.

E. **Dielectric-Flange Kits:** Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Manufacturers:
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Central Plastics Company.
   d. Pipeline Seal and Insulator, Inc.
   e. Or Approved Substitute.

2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. **Dielectric Couplings:** Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

1. Manufacturers:
   a. Calpico, Inc.
   b. Lochinvar Corp.
   c. Or Approved Substitute.
G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

1. Manufacturers:
   a. Perfection Corp.
   b. Precision Plumbing Products, Inc.
   c. Sioux Chief Manufacturing Co., Inc.
   d. Victaulic Co. of America.
   e. Or Approved Substitute.

2.6 SLEEVES
A. Galvanized-Steel Sheet: G90, 16 gauge minimum thickness; round tube closed with welded longitudinal joint.
B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.
C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
D. 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 set screws.

2.7 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 set screw.
   1. Finish: Polished chrome-plated.
D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
   1. Finish: Polished chrome-plated.
E. One-Piece, Stamped-Steel Type: With set screw and chrome-plated finish.
F. One-Piece, Floor-Plate Type: Cast-iron floor plate.
G. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.8 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 PLUMBING DEMOLITION

A. Refer to Division 2 Section 024114 "Selective Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove plumbing systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping as specified.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were
used to size pipe and calculate friction loss, expansion, pump sizing, and other
design considerations. Install piping as indicated unless deviations to layout
are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in
equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and
service areas at right angles or parallel to building walls. Diagonal runs are
prohibited unless specifically indicated otherwise.

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

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system
operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to
the following:

1. New Piping:
   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece,
deepl-pattern type.
   b. Chrome-Plated Piping: One-piece, cast-brass type with polished
   chrome-plated finish.
   c. Insulated Piping: One-piece, stamped-steel type with spring clips.
   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,
cast-brass type with polished chrome-plated finish.
   g. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass
type with polished chrome-plated finish.
   h. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
   i. Bare Piping in Equipment Rooms: One-piece, stamped-steel type
   with set screw.
   j. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece,
floor-plate type.
2. Existing Piping: Use the following:
   a. Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
   b. Insulated Piping: Split-plate, stamped-steel type with concealed hinge and spring clips.
   c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
   e. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
   f. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
   g. Bare Piping in Unfinished Service Spaces: Split-casting, cast-brass type with polished chrome-plated finish.
   h. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed hinge and set screw or spring clips.
   i. Bare Piping in Equipment Rooms: Split-casting, cast-brass type.
   j. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
   k. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.

M. Sleeves are not required for core-drilled holes.

N. Permanent sleeves are not required for holes formed by removable PE sleeves.

O. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

P. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, 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 walls and slabs as walls and slabs are modified.

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.
   b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
c. 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.

1) 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.

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

1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

R. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for 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.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

S. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials.

T. Verify final equipment locations for roughing-in.

U. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and specified sections.
B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.


F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
4. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
5. PVC Nonpressure Piping: Join according to ASTM D 2855.
6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.

J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
K. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

L. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

M. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer’s written instructions.

3.4 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

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

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

C. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

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

3.6 PAINTING

A. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.
3.7 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

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

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.

B. Field Welding: Comply with AWS D1.1.

3.9 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor plumbing materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.10 GROUTING

A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.
D. Avoid air entrapment during placement of grout.
E. Place grout, completely filling equipment bases.
F. Place grout on concrete bases and provide smooth bearing surface for equipment.
G. Place grout around anchors.
H. Cure placed grout.

END OF SECTION 220500
SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Fiberglass pipe hangers.
4. Metal framing systems.
5. Fiberglass strut systems.
6. Thermal-hanger shield inserts.
7. Fastener systems.
8. Pipe stands.
9. Pipe positioning systems.
10. Equipment supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of the Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:
   1. Trapeze pipe hangers.
   2. Metal framing systems.
   3. Fiberglass strut systems.
   4. Pipe stands.
   5. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Detail fabrication and assembly of trapeze hangers.
   2. Design Calculations: Calculate requirements for designing trapeze hangers.

D. Welding certificates.

1.6 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Copper Pipe Hangers:
   1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel Insert material.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Carpenter & Paterson, Inc.
3. ERICO International Corporation.
5. PHS Industries, Inc.
6. Pipe Shields, Inc.; a subsidiary of Piping Technology & Products, Inc.
7. Piping Technology & Products, Inc.
8. Rilco Manufacturing Co., Inc.
9. Value Engineered Products, Inc.

B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength.

D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.4 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
2.5 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece plastic base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand:
   1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
   3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
   4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand:
   1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
   2. Bases: One or more; plastic.
   3. Vertical Members: Two or more protective-coated-steel channels.
   4. Horizontal Member: Protective-coated-steel channel.
   5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.6 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, positioning system of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

2.7 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.
2.8 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, non-shrink and nonmetallic grout; suitable for interior and exterior applications.
   2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. All newly installed work shall be properly secured, anchored and braced. Existing to remain work anchoring, barring, and support shall not be compromised by the new work.

B. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

C. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
   2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

D. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.

E. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

F. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled fiberglass struts.

G. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

H. Fastener System Installation:
1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.

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

I. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.

2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb.

J. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.

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


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

N. Install lateral bracing with pipe hangers and supports to prevent swaying.

O. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

P. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

Q. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

R. Insulated Piping:

1. Attach clamps and spacers to piping.
   
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. 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.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

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

3.4 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

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 a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Structural and Engineering specifications

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel metal trapeze pipe hangers and attachments for general service applications.

F. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

G. Use padded hangers for piping that is subject to scratching.

H. Use thermal-hanger shield inserts for insulated piping and tubing.

I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of non-insulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.

18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.

19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.

21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.

2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.

2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.

4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.

5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.

2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.

3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.

4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.

5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.

6. C-Clamps (MSS Type 23): For structural shapes.
7. **Top-Beam Clamps (MSS Type 25):** For top of beams if hanger rod is required tangent to flange edge.
8. **Side-Beam Clamps (MSS Type 27):** For bottom of steel I-beams.
9. **Steel-Beam Clamps with Eye Nuts (MSS Type 28):** For attaching to bottom of steel I-beams for heavy loads.
10. **Linked-Steel Clamps with Eye Nuts (MSS Type 29):** For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. **Malleable-Beam Clamps with Extension Pieces (MSS Type 30):** For attaching to structural steel.
12. **Welded-Steel Brackets:** For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
   a. **Light (MSS Type 31):** 750 lb.
   b. **Medium (MSS Type 32):** 1500 lb.
   c. **Heavy (MSS Type 33):** 3000 lb.
13. **Side-Beam Brackets (MSS Type 34):** For sides of steel or wooden beams.
14. **Plate Lugs (MSS Type 57):** For attaching to steel beams if flexibility at beam is required.
15. **Horizontal Travelers (MSS Type 58):** For supporting piping systems subject to linear horizontal movement where headroom is limited.

**M. Saddles and Shields:** Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. **Steel-Pipe-Covering Protection Saddles (MSS Type 39):** To fill interior voids with insulation that matches adjoining insulation.
2. **Protection Shields (MSS Type 40):** Of length recommended in writing by manufacturer to prevent crushing insulation.
3. **Thermal-Hanger Shield Inserts:** For supporting insulated pipe.

**N. Spring Hangers and Supports:** Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. **Restraint-Control Devices (MSS Type 47):** Where indicated to control piping movement.
2. **Spring Cushions (MSS Type 48):** For light loads if vertical movement does not exceed 1-1/4 inches.
3. **Spring-Cushion Roll Hangers (MSS Type 49):** For equipping Type 41, roll hanger with springs.
4. **Spring Sway Braces (MSS Type 50):** To retard sway, shock, vibration, or thermal expansion in piping systems.
5. **Variable-Spring Hangers (MSS Type 51):** Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. **Variable-Spring Base Supports (MSS Type 52):** Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.

8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
   a. Horizontal (MSS Type 54): Mounted horizontally.
   b. Vertical (MSS Type 55): Mounted vertically.
   c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

O. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

P. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

Q. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

R. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 220529
SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Stencils.
5. Valve tags.
6. Warning tags.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.
PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch Insert dimension thick, and having predrilled holes for attachment hardware.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.
2.2  WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black.

C. Background Color: Yellow.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3  PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pre-tensioned Pipe Labels: Pre-coiled, semi-rigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

   1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions; or, as separate unit on each pipe label to indicate flow direction.

   2. Lettering Size: At least 1-1/2 inches high.
2.4 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.

2. Stencil Paint: Exterior, gloss, alkyd enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
3. Identification Paint: Exterior, alkyd enamel in colors according to ASME A13.1 unless otherwise indicated.

2.5 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass beaded chain.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.6 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulates.
3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in other sections

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels with painted, color-coded bands or rectangles, complying with ASME A13.1, on each piping system.

1. Identification Paint: Use for contrasting background.

C. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

D. Pipe Label Color Schedule:

1. Low-Pressure, Compressed-Air Piping:
   a. Background Color: Yellow.
   b. Letter Color: Black.

2. Medium-Pressure, Compressed-Air Piping:
   a. Background Color: Yellow.
   b. Letter Color: Black.
3. Domestic Water Piping:
   a. Background Color: Blue.
   b. Letter Color: Black.

4. Sanitary Waste Piping:
   a. Background Color: Green.
   b. Letter Color: Black.

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:
   b. Hot Water: 2 inches, round.
   c. Low-Pressure Compressed Air: 2 inches, round.
   d. High-Pressure Compressed Air: 2 inches, round.

2. Valve-Tag Color:
   b. Hot Water: Natural.
   c. Low-Pressure Compressed Air: Natural.
   d. High-Pressure Compressed Air: Natural.

3. Letter Color:
   b. Hot Water: Black.
   c. Low-Pressure Compressed Air: Black.
   d. High-Pressure Compressed Air: Black.

3.5 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.
SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes domestic water piping and water meters inside the building.
B. Water meters will be furnished and installed by utility company.
C. Water meters will be furnished by utility company for installation by Contractor.

1.3 DEFINITIONS

A. CPVC: Chlorinated polyvinyl chloride plastic.
B. PEX: Crosslinked polyethylene plastic.
C. PVC: Polyvinyl chloride plastic.

1.4 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing domestic water piping systems with 80 psig, unless otherwise indicated.

1.5 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings and water meters.
C. Field quality-control test reports.
1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.


C. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9," for potable domestic water piping and components.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 PIPING MATERIALS

A. Refer to Part 3 "Pipe and Fitting Applications" Article for applications of pipe, tube, fitting, and joining materials.

B. Transition Couplings for Aboveground Pressure Piping: Coupling or other manufactured fitting the same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.3 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Types L, water tube, drawn temper.


   2. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

2.4 VALVES

A. Bronze and Brass, general-duty valves as specified.

B. Balancing and drain valves as specified.
2.5 WATER METERS

A. Displacement-Type Water Meters: Same size as line being served. AWWA C700, nutating-disc totalizing meter with bronze case and 150-psig minimum working-pressure rating; with registration in gallons as required by utility.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB.
   b. Badger Meter, Inc.
   c. Hays Fluid Controls.
   d. Master Meter, Inc.
   e. Metering Systems.

B. Remote Registration System: Direct-reading type complying with AWWA C706; modified with signal transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Excavating, trenching, and backfilling as specified.

3.2 PIPE AND FITTING APPLICATIONS

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.

B. Flanges may be used on aboveground piping, unless otherwise indicated.

C. Grooved joints may be used on aboveground grooved-end piping.

D. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.

E. Under-Building-Slab, Water-Service Piping on Service Side of Water Meter as specified.

F. Domestic Water Piping on Service Side of Water Meter inside the Building: Use any of the following piping materials for each size range:

   1. NPS 1” to 6”: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
G. Under-Building-Slab, Domestic Water Piping on House Side of Water Meter, NPS 4 and Smaller: Soft copper tube, Type K; copper pressure fittings; and soldered joints.

H. Aboveground Domestic Water Piping: Use any of the following piping materials for each size range:
   1. NPS 1 and Smaller: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
   2. NPS 1-1/4 and NPS 1-1/2: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
   3. NPS 2: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
   4. NPS 2-1/2 to NPS 3-1/2: Hard copper tube, Type L; copper groove fittings; grooved-end tube couplings; and grooved joints.
   5. NPS 2-1/2 to NPS 4: Hard copper tube, Type L with grooved ends; copper grooved-end fittings; grooved-end-tube couplings; and grooved joints.

I. Non-Potable-Water Piping: Use any of the following piping materials for each size range:
   1. NPS 3-1/2 and Smaller: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
   2. NPS 3-1/2 and Smaller: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
   3. NPS 4 to NPS 6: Hard copper tube, Type L; copper pressure fittings; and soldered joints.

3.3 VALVE APPLICATIONS

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
   1. Shutoff Duty: Use bronze ball or gate valves for piping NPS 2 and smaller. Use cast-iron butterfly or gate valves with flanged ends for piping NPS 2-1/2 and larger.
   2. Throttling Duty: Use bronze ball or globe valves for piping NPS 2 and smaller. Use cast-iron butterfly valves with flanged ends for piping NPS 2-1/2 and larger.

B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball or gate valves for piping NPS 2 and smaller. Use butterfly or gate valves for piping NPS 2-1/2 and larger.
C. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping.

1. Install hose-end drain valves at low points in water mains, risers, and branches.
2. Install stop-and-waste drain valves where indicated.

D. Install balancing valve in each hot-water circulation return branch and discharge side of each pump and circulator. Set balancing valves partly open to restrict but not stop flow. Use ball valves for piping NPS 2 and smaller and butterfly valves for piping NPS 2-1/2 and larger. Balancing valves are specified in Section 2201119 "Domestic Water Piping Specialties."

E. Install calibrated balancing valves in each hot-water circulation return branch and discharge side of each pump and circulator. Set calibrated balancing valves partly open to restrict but not stop flow. Calibrated balancing valves are specified in Section 2201119 "Domestic Water Piping Specialties."

3.4 PIPING INSTALLATION

A. Basic piping installation requirements are specified in Section 220500 "Common Work Results for Plumbing."

B. Install under-building-slab copper tubing according to CDA's "Copper Tube Handbook."

C. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Section 220500 "Common Work Results for Plumbing."

D. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Wall penetration systems are specified in Section 220500 "Common Work Results for Plumbing."

E. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Pressure gages as specified, and drain valves and strainers are specified in Section 221119 "Domestic Water Piping Specialties."

F. Install water-pressure regulators downstream from shutoff valves. Water-pressure regulators are specified in Section 221119 "Domestic Water Piping Specialties."

G. Install domestic water piping level without pitch and plumb.
H. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

3.5 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Section 220500 "Common Work Results for Plumbing."

B. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.6 WATER METER INSTALLATION

A. Rough-in domestic water piping for water meter installation according to utility company's requirements.

B. Water meters will be furnished and installed by utility company.

C. Install water meters according to AWWA M6 and utility's requirements.

3.7 HANGER AND SUPPORT INSTALLATION

A. Seismic-restraint devices as specified.

B. Pipe hanger and support devices are specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment." Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.

2. Individual, Straight, Horizontal Piping Runs: According to the following:

   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet: MSS Type 49, spring cushion rolls, if indicated.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.

4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install supports according to Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

D. Support vertical piping and tubing at base and at each floor.
E. Rod diameter may be reduced 1 size for double-rod hangers, to a minimum of 3/8 inch.

F. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 and Smaller: 84 inches with 3/8-inch rod.
2. NPS 1-1/2: 108 inches with 3/8-inch rod.
3. NPS 2: 10 feet with 3/8-inch rod.
4. NPS 2-1/2: 11 feet with 1/2-inch rod.
5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.
6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
7. NPS 6: 12 feet with 3/4-inch rod.
8. NPS 8 to NPS 12: 12 feet with 7/8-inch rod.

G. Install supports for vertical steel piping every 15 feet.

H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
4. NPS 2-1/2: 108 inches with 1/2-inch rod.
5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
6. NPS 6: 10 feet with 5/8-inch rod.
7. NPS 8: 10 feet with 3/4-inch rod.

I. Install supports for vertical copper tubing every 10 feet.

J. Install hangers for CPVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1 and Smaller: 36 inches with 3/8-inch rod.
2. NPS 1-1/4 to NPS 2: 48 inches with 3/8-inch rod.
3. NPS 2-1/2 to NPS 3-1/2: 48 inches with 1/2-inch rod.
4. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
5. NPS 6: 48 inches with 3/4-inch rod.
6. NPS 8: 48 inches with 7/8-inch rod.

K. Install supports for vertical CPVC piping every 60 inches for NPS 1 and smaller, and every 72 inches for NPS 1-1/4 and larger.

L. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2 and Smaller: 48 inches with 3/8-inch rod.
2. NPS 2-1/2 to NPS 3-1/2: 48 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
4. NPS 6: 48 inches with 3/4-inch rod.
5. NPS 8: 48 inches with 7/8-inch rod.
M. Install supports for vertical PVC piping every 48 inches.

N. Support piping and tubing not listed above according to MSS SP-69 and manufacturer’s written instructions.

3.8 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment and machines to allow service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve, and extend and connect to the following with flex connectors at each piece of equipment:

1. Booster Pumps: Cold-water suction and discharge piping.
2. Water Heaters: Cold-water supply and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
3. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code.
4. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.9 FIELD QUALITY CONTROL

A. Inspect domestic water piping as follows:

1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
2. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
   a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
   b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
3. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

B. Test domestic water piping as follows:

1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
4. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.10 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
   a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch.
   b. Adjust calibrated balancing valves to flows indicated.
5. Remove plugs used during testing of piping and plugs used for temporary sealing of piping during installation.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.
3.11 CLEANING

A. Clean and disinfect potable and non-potable domestic water piping as follows:

1. Purge new piping and parts of existing domestic water piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction or, if methods are not prescribed, procedures described in either AWWA C651 or AWWA C652 or as described below:

   a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
   b. Fill and isolate system according to either of the following:

      1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
      2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.

   c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
   d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

B. Prepare and submit reports of purging and disinfecting activities.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

END OF SECTION 221116
SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Vacuum breakers.
2. Backflow preventers.
5. Temperature-actuated, water mixing valves.
7. Outlet boxes.
8. Hose stations.
9. Hose bibbs.
10. Wall hydrants.
12. Post hydrants.
15. Air vents.
16. Trap-seal primer valves.
17. Trap-seal primer systems.
19. Flexible connectors.
20. Water meters.

1.3 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For domestic water piping specialties.

1. Include diagrams for power, signal, and control wiring.

C. Field quality-control reports.
D. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

A. Potable-water piping and components shall comply with NSF 61 and NSF 14.

2.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

2.3 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
   b. Cash Acme; a division of Reliance Worldwide Corporation.
   c. Conbraco Industries, Inc.
   d. FEBCO; a division of Watts Water Technologies, Inc.
   e. Rain Bird Corporation.
   f. Toro Company (The); Irrigation Div.
   g. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
   h. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
   i. Or Approved Substitute.

3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
5. Inlet and Outlet Connections: Threaded.
6. Finish: Chrome plated.

B. Hose-Connection Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Arrowhead Brass Products.
   b. Cash Acme; a division of Reliance Worldwide Corporation.
2.4 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Cash Acme; a division of Reliance Worldwide Corporation.
   b. Conbraco Industries, Inc.
   c. Honeywell International Inc.
   d. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
   e. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
   f. Or Approved Substitute.

4. Body: Bronze for NPS 2 and smaller; cast iron for NPS 2-1/2 and NPS 3.
5. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

2.5 BALANCING VALVES

A. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

B. Memory-Stop Balancing Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Crane Co.; Crane Valve Group; Jenkins Valves.
   d. Crane Co.; Crane Valve Group; Stockham Div.
   e. Hammond Valve.
   f. Milwaukee Valve Company.
   g. NIBCO Inc.
   h. Red-White Valve Corp.
   i. Or Approved Substitute.

2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
3. Pressure Rating: 400-psig minimum CWP.
4. Size: NPS 2 or smaller.
5. Body: Copper alloy.
6. Port: Standard or full port.
7. Ball: Chrome-plated brass.
8. Seats and Seals: Replaceable.
9. End Connections: Solder joint or threaded.

2.6 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Primary, Thermostatic, Water Mixing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Lawler Manufacturing Company, Inc.
   c. Leonard Valve Company.
   d. Powers; a division of Watts Water Technologies, Inc.
   e. Symmons Industries, Inc.
   f. Or Approved Substitute.

3. Pressure Rating: 125 psi minimum unless otherwise indicated.
4. Type: Exposed-mounted, thermostatically controlled, water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded union inlets and outlet.
7. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Tempered-Water Setting: 110 deg F
2.7 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig minimum unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations unless otherwise indicated.
5. Perforation Size:
   a. Strainers NPS 2 and Smaller: 0.020 inch.
   b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch.

2.8 HOSE BIBBS

4. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Service Areas: Chrome or nickel plated.
10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Wheel handle or operating key.
12. Operation for Service Areas: Operating key.
14. Include operating key with each operating-key hose bibb.
15. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.9 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:

2. Pressure Rating: 400-psig minimum CWP.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
8. Inlet: Threaded or solder joint.

2.10 WATER-HAMMER ARRESTERS

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMTROL, Inc.
   b. Josam Company.
   c. MIFAB, Inc.
   d. Precision Plumbing Products, Inc.
   e. Sioux Chief Manufacturing Company, Inc.
   g. Tyler Pipe; Wade Div.
   h. Watts Drainage Products.
   i. Zurn Industries, LLC; Plumbing Products Group; Specification Drainage Products.
   j. Or Approved Substitute.

3. Type: Metal bellows.
4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.11 AIR VENTS

A. Bolted-Construction Automatic Air Vents:
   1. Body: Bronze.
   2. Pressure Rating and Temperature: 125-psig minimum pressure rating at 140 deg F.
   3. Float: Replaceable, corrosion-resistant metal.

2.12 TRAP-SEAL PRIMER DEVICE

A. Supply-Type, Trap-Seal Primer Device
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. MIFAB, Inc.
      b. Precision Plumbing Products, Inc.
      c. Sioux Chief Manufacturing Company, Inc.
e. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
f. Or Approved Substitute.

5. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
6. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
7. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

2.13 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Flex-Hose Co., Inc.
2. Flexicraft Industries.
3. Flex Pression, Ltd.
4. Flex-Weld Incorporated.
5. Hyspan Precision Products, Inc.
7. Metraflex, Inc.
8. Proco Products, Inc.
9. TOZEN Corporation.
10. Unaflex.Universal Metal Hose; a Hyspan company.
11. Or Approved Substitute.

B. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.

2. End Connections NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
3. End Connections NPS 2-1/2 and Larger: Flanged copper alloy.

2.14 WATER METERS

A. Turbine-Type Water Meters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. AALIANT; a Venture Measurement product line.
   b. ABB.
   c. Badger Meter, Inc.
   d. Hays Fluid Controls.
   e. Master Meter, Inc.
2. Description:
   b. Pressure Rating: 150-psig working pressure.
   c. Body Design: Turbine; totalization meter.
   d. Registration: In gallons or cubic feet as required by utility company.
   e. Case: Bronze.
   f. End Connections for Meters NPS 2 and Smaller: Threaded.
   g. End Connections for Meters NPS 2-1/2 and Larger: Flanged.

B. Remote Registration System: Direct-reading type complying with AWWA C706; modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility company.

C. Remote Registration System: Encoder type complying with AWWA C707; modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility company.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install water regulators with inlet and outlet shutoff valves. Install pressure gages on inlet and outlet.

B. Install balancing valves in locations where they can easily be adjusted.

C. Install temperature-actuated, water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
   1. Install cabinet-type units recessed in or surface mounted on wall as specified.

D. Install Y-pattern strainers for water on supply side of each water pressure-reducing valve and pump.

E. Install outlet boxes recessed in wall or surface mounted on wall. Install 2-by-4-inch fire-retardant-treated-wood blocking, wall reinforcement between studs. Comply with requirements for fire-retardant-treated-wood blocking.

F. Install water-hammer arresters in water piping according to PDI-WH 201.
G. Install air vents at high points of water piping. Install drain piping and discharge onto floor drain.

H. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

I. Install drainage-type, trap-seal primer valves as lavatory trap with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting.

J. Install trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

3.2 CONNECTIONS

A. Comply with requirements for ground equipment.

3.3 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Pressure vacuum breakers.
2. Intermediate atmospheric-vent backflow preventers.
3. Reduced-pressure-principle backflow preventers.
5. Carbonated-beverage-machine backflow preventers.
7. Reduced-pressure-detector, fire-protection, backflow-preventer assemblies.
10. Calibrated balancing valves.
11. Primary, thermostatic, water mixing valves.
14. Primary water tempering valves.
15. Outlet boxes.
17. Supply-type, trap-seal primer valves.
18. Trap-seal primer systems.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Comply with nameplates and signs as specified.
3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test each pressure vacuum breaker according to authorities having jurisdiction and the device’s reference standard.

B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow set points of balancing valves.

C. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

END OF SECTION 221119
SECTION 230516 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Flexible-hose packless expansion joints.
2. Metal-bellows packless expansion joints.
3. Pipe loops and swing connections.
4. Alignment guides and anchors.

1.3 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Welding certificates.

C. Product Certificates: For each type of expansion joint, from manufacturer.

D. Maintenance Data: For expansion joints to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. ASME Boiler and Pressure Vessel Code: Section IX.
PART 2 - PRODUCTS

2.1 PACKLESS EXPANSION JOINTS

A. Flexible-Hose Packless Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
a. Mason Industries, Inc.
b. Metraflex Company (The).
c. Unisource Manufacturing, Inc.
d. Or Approved Substitute.

2. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.

3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.

4. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with solder-joint end connections.
   
a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.
b. Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F and 500 psig at 450 deg F ratings.

5. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6: Carbon-steel fittings with flanged or weld end connections.
   
a. Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F and 200 psig at 600 deg F ratings.

6. Expansion Joints for Steel Piping NPS 8 to NPS 12: Carbon-steel fittings with flanged or weld end connections.
   
a. Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F and 120 psig at 600 deg F ratings.

7. Expansion Joints for Steel Piping NPS 14 and Larger: Carbon-steel fittings with flanged or weld end connections.
   
a. Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F and 120 psig at 600 deg F ratings.

B. Metal-Bellows Packless Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
a. Flex-Hose Co., Inc.
b. Mason Industries, Inc.
c. Metraflex Company (The).
d. Or Approved Substitute.


3. Type: Circular, corrugated bellows with external tie rods.

4. Minimum Pressure Rating: 175 psig unless otherwise indicated.

5. Configuration: Single joint with base and double joint with base class(es) unless otherwise indicated.

6. Expansion Joints for Copper Tubing Multi-ply phosphor-bronze bellows, copper pipe ends, and brass shrouds.
   a. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint

   a. End Connections for Steel Pipe NPS 2-1/2 and Larger: Flanged or Weld.

2.2 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Mason Industries, Inc.
   b. Metraflex Company (The).
   c. U.S. Bellows, Inc.
   d. Or Approved Substitute.

2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider for bolting to pipe.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A 36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
5. Chemical Fasteners: Insert-type-stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
   
a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
   
   

PART 3 - EXECUTION

3.1 EXPANSION-JOINT INSTALLATION
   
A. Installation of any joints shall not compromise exiting to remain HVAC systems.
   
B. Install expansion joints of sizes matching sizes of piping in which they are installed.
   
C. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION
   
A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
   
B. Connect risers and branch connections to mains with at least five pipe fittings including tee in main.
   
C. Connect risers and branch connections to terminal units with at least four pipe fittings including tee in riser.
   
D. Connect mains and branch connections to terminal units with at least four pipe fittings including tee in main.

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION
   
A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
   
B. Install one guide on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.
   
C. Attach guides to pipe and secure guides to building structure.
D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:
   2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24, U-bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
   1. Anchor Attachment to Steel Structural Members: Attach by welding.
   2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 230516
SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Sleeves.
   2. Stack-sleeve fittings.
   3. Sleeve-seal systems.
   4. Sleeve-seal fittings.
   5. Grout.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.


E. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
G. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE 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:

B. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or comparable product by one of the following:

2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.
3. Or Approved Substitute.

C. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

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 the product indicated on Drawings or comparable product by one of the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.
6. Or Approved Substitute.

C. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM-rubber or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel or stainless steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.
2.4 SLEEVE-SEAL 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:

B. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or comparable product by one of the following:

1. Presealed Systems.
2. Or Approved Substitute

C. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT


B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. 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.

3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants as specified.

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping as specified.

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing as specified.
3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping as specified.

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against
pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 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.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:
   a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves or Galvanized-steel-pipe sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel wall sleeves or Galvanized-steel-pipe sleeves.

2. Exterior Concrete Walls below Grade:
   a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves with sleeve-seal system or Galvanized-steel-pipe sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Galvanized-steel wall sleeves with sleeve-seal system or Galvanized-steel-pipe sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:
   a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves with sleeve-seal system or Galvanized-steel-pipe sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
b. Piping NPS 6 and Larger: Galvanized-steel wall sleeves with sleeve-seal system or Galvanized-steel-pipe sleeves with sleeve-seal system or Galvanized-steel-pipe sleeves.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:

b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.

5. Interior Partitions:

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following hangers and supports for mechanical system piping and equipment:

1. Steel pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Pipe positioning systems.
8. Equipment supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry Inc.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.
1.5 SUBMITTALS

A. Product Data: For the following:
   1. Steel pipe hangers and supports.
   2. Thermal-hanger shield inserts.
   3. Pipe positioning systems.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:
   1. Trapeze pipe hangers. Include Product Data for components.
   2. Metal framing systems. Include Product Data for components.
   3. Pipe stands. Include Product Data for components.
   4. Equipment supports.

C. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to the following:
   1. AWS D1.1, "Structural Welding Code--Steel."
   4. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
   5. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Manufacturers:
   1. Tolco Inc.
2. B-Line Systems, Inc.; a division of Cooper Industries.
3. Grinnell Corp.
4. Or Approved Substitute.

C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.4 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Manufacturers:

2. Tolco Inc.
3. Unistrut Corp.; Tyco International, Ltd.
4. Or Approved Substitute.

C. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.5 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Manufacturers:

1. Carpenter & Paterson, Inc.
2. ERICO/Michigan Hanger Co.
3. PHS Industries, Inc.
4. Pipe Shields, Inc.
5. Rilco Manufacturing Company, Inc.
6. Value Engineered Products, Inc.
7. Or Approved Substitute.

C. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with vapor barrier.

D. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate.

E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

   1. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: Insert-wedge-type stainless steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

   1. Manufacturers:

      a. Hilti, Inc.
      b. ITW Ramset/Red Head.
      c. Mason Industries Type SAB
      d. Or Approved Substitute.

2.7 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, system of metal brackets, clips, and straps for positioning piping in pipe spaces for plumbing fixtures for commercial applications.

B. Manufacturers:

   2. HOLDRITE Corp.; Hubbard Enterprises.
   3. Samco Stamping, Inc.
   4. Or Approved Substitute.

2.8 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.
2.9 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.


      a. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use padded hangers for piping that is subject to scratching.

F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
   2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
   3. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
   4. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
   5. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.

G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

   1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
   a. Light (MSS Type 31): 750 lb.
   b. Medium (MSS Type 32): 1500 lb.
   c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

K. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
   a. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
2. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
3. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
4. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.
5. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
   a. Horizontal (MSS Type 54): Mounted horizontally.
   b. Vertical (MSS Type 55): Mounted vertically.
   c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

L. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.

M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

N. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

O. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.
3.2 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.

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

2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:

1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer’s written instructions.

F. Pipe Positioning System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.

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


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

J. Install lateral bracing with pipe hangers and supports to prevent swaying.

1. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
K. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

M. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping.
   a. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   b. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. 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.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. Pipes NPS 8 and Larger: Include wood inserts.

5. Insert Material: Length at least as long as protective shield.

6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.
C. Provide lateral bracing, to prevent swaying, for equipment supports, duct supports, and piping supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:

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

3.5 ADJUSTING

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

1. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide 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 230529
SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.
5. Stencils.
6. Valve tags.
7. Warning tags.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Samples: For color, letter style, and graphic representation required for each identification material and device.
C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
D. Valve numbering scheme.
E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
B. Coordinate installation of identifying devices with locations of access panels and doors.
C. Install identifying devices before installing acoustical ceilings and similar concealment.
D. Coordinate installation of piping such that pipe labels for overhead piping are visible on bottom of pipe.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:
   1. Material and Thickness: Brass, 0.032-inch, Stainless steel, 0.025-inch, Aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
   3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
   5. Adhesive: Contact-type permanent adhesive, compatible with label and substrate.

B. Plastic Labels for Equipment:
   1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
   4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
   5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
   6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
   7. Fasteners: Stainless-steel rivets or self-tapping screws.
   8. Adhesive: Contact-type permanent adhesive, compatible with label and substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.
D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2 by 11 inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

1. In addition to the physical copy required above, provide equipment label schedule in digital form. File format shall be comma separated values (CSV) or equivalent open format.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Yellow.

C. Background Color: Red.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

C. Pipe Label Contents: Include identification of piping service, pipe size, and an arrow indicating flow direction.
1. Piping Service Designation: Identify piping system with designations as follows:
   a. Chilled Water Supply (Low-Temperature Chilled Water): CHWS
   b. Chilled Water Return (High-Temperature Chilled Water): CHWR
   c. Heating Hot Water Supply (High-Temperature Heating Hot Water): HHWS
   d. Heating Hot Water Return (Low-Temperature Heating Hot Water): HHWR

2. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
3. Lettering Size: At least 1-1/2 inches high.

2.4 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
B. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
C. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
D. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
E. Fasteners: Stainless-steel rivets or self-tapping screws.
F. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
G. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
   2. Lettering Size: At least 1-1/2 inches high.

2.5 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
1. Tag Material: Brass, 0.032-inch Stainless steel, 0.025-inch Aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link or beaded chain; or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2 by 11 inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.6 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches.
2. Fasteners: Reinforced grommet and wire or string.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

B. Pipe Label Color Schedule:

1. Chilled-Water Piping:
   a. Background Color: Blue.

2. Heating Water Piping:
   a. Background Color: Red

3.4 DUCT LABEL INSTALLATION

A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue For cold-air supply ducts.
2. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
3. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:
   b. Hot Water: 2 inches, round.

2. Valve-Tag Color:
   b. Hot Water: Natural.

3. Letter Color:
   b. Hot Water: Black.

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required by the California Code of Regulations, Title 24, or where required or recommended by the equipment manufacturer.

B. Provide warning tags for all rooftop hydronic piping with text reading “NO STEP”. Provide at intervals no greater than 10’-0” for each piping run and at locations where access requires crossing rooftop piping.

END OF SECTION 230553
SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Balancing Air Systems:
      a. Constant-volume air systems.
      b. Variable-air-volume systems.
   2. Balancing Hydronic Piping Systems:
      a. Variable-flow hydronic systems.

1.3 DEFINITIONS


B. TAB: Testing, adjusting, and balancing.

C. TABB: Testing, Adjusting, and Balancing Bureau.

D. TAB Specialist: An entity engaged to perform TAB Work.

1.4 SUBMITTALS

A. Qualification Data: Within 15 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.


D. Certified TAB reports.

E. Sample report forms.

F. Instrument calibration reports, to include the following:
   1. Instrument type and make.
   2. Serial number.
   3. Application.
   4. Dates of use.
   5. Dates of calibration.

1.5 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by NEBB.
   1. TAB Field Supervisor: Employee of the TAB contractor and certified by NEBB.
   2. TAB Technician: Employee of the TAB contractor and who is certified by NEBB as a TAB technician.

B. Certify TAB field data reports and perform the following:
   1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
   2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

C. TAB Report Forms: Use standard TAB contractor's forms approved by Engineer.

D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

1.6 COORDINATION

A. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems’ designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems’ output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA’s "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

F. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

G. Examine test reports specified in individual system and equipment Sections.

H. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

I. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

J. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.
K. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

M. Examine system pumps to ensure absence of entrained air in the suction piping.

N. Examine operating safety interlocks and controls on HVAC equipment.

O. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare reports. Verify the following:

1. Permanent electrical-power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish as specified.

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and
devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified.

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

   a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.
2. Measure fan static pressures as follows to determine actual static pressure:
   
a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
   
b. Measure static pressure directly at the fan outlet or through the flexible connection.
   
c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
   
d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
   
a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.

5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.

6. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.

7. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure airflow of submain and branch ducts.

   a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer’s written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer’s recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
3. Measure total system airflow. Adjust to within indicated airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer’s written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.

6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

   a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.

8. Record final fan-performance data.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check liquid level in expansion tank.
3. Check makeup water-station pressure gage for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation, and set at indicated flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.8 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.
3.9 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.10 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load and at each incremental stage.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Air pressure drop.
4. Inlet steam pressure.

D. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.11 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
   1. Measure and record the operating speed, airflow, and static pressure of each fan.
   2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
   3. Check the refrigerant charge.
   4. Check the condition of filters.
   5. Check the condition of coils.
   6. Check the operation of the drain pan and condensate-drain trap.
   7. Check bearings and other lubricated parts for proper lubrication.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:
   1. New filters are installed.
   2. Coils are clean and fins combed.
   3. Drain pans are clean.
   4. Fans are clean.
   5. Bearings and other parts are properly lubricated.
   6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
   1. Compare the indicated airflow of the renovated work to the measured fan airflow, and determine the new fan speed and the face velocity of filters and coils.
   2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
   3. If calculations increase or decrease the air flow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
   4. Balance each air outlet.
3.12 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans:  Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Heating-Water Flow Rate:  Plus or minus 10 percent
4. Cooling-Water Flow Rate:  Plus or minus 10 percent.

3.13 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

3.14 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB contractor.
3. Project name.
4. Project location.
5. Engineer's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
   a. Indicated versus final performance.
   b. Notable characteristics of systems.
   c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer’s name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:
   a. Settings for outdoor-, return-, and exhaust-air dampers.
   b. Conditions of filters.
   c. Cooling coil, wet- and dry-bulb conditions.
   d. Face and bypass damper settings at coils.
   e. Fan drive settings including settings and percentage of maximum pitch diameter.
   f. Inlet vane settings for variable-air-volume systems.
   g. Settings for supply-air, static-pressure controller.
   h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
   1. Quantities of outdoor, supply, return, and exhaust airflows.
   2. Water and steam flow rates.
   3. Duct, outlet, and inlet sizes.
   4. Pipe and valve sizes and locations.
   5. Terminal units.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
   1. Unit Data:
      a. Unit identification.
      b. Location.
      c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Unit arrangement and class.
g. Discharge arrangement.
h. Sheave make, size in inches, and bore.
i. Center-to-center dimensions of sheave, and amount of adjustments in inches.
j. Number, make, and size of belts.
k. Number, type, and size of filters.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

a. Total air flow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Filter static-pressure differential in inches wg.
f. Preheat-coil static-pressure differential in inches wg.
g. Cooling-coil static-pressure differential in inches wg.
h. Heating-coil static-pressure differential in inches wg.
i. Outdoor airflow in cfm.
j. Return airflow in cfm.
k. Outdoor-air damper position.
l. Return-air damper position.
m. Vortex damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch o.c.
f. Make and model number.
g. Face area in sq. ft.
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.
2. **Test Data (Indicated and Actual Values):**
   a. Air flow rate in cfm.
   b. Average face velocity in fpm.
   c. Air pressure drop in inches wg.
   d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
   e. Return-air, wet- and dry-bulb temperatures in deg F.
   f. Entering-air, wet- and dry-bulb temperatures in deg F.
   g. Leaving-air, wet- and dry-bulb temperatures in deg F.
   h. Water flow rate in gpm.
   i. Water pressure differential in feet of head or psig.
   j. Entering-water temperature in deg F.
   k. Leaving-water temperature in deg F.
   l. Refrigerant expansion valve and refrigerant types.
   m. Refrigerant suction pressure in psig.
   n. Refrigerant suction temperature in deg F.
   o. Inlet steam pressure in psig.

G. **Fan Test Reports:** For supply, return, and exhaust fans, include the following:

1. **Fan Data:**
   a. System identification.
   b. Location.
   c. Make and type.
   d. Model number and size.
   e. Manufacturer's serial number.
   f. Arrangement and class.
   g. Sheave make, size in inches, and bore.
   h. Center-to-center dimensions of sheave, and amount of adjustments in inches.

2. **Motor Data:**
   a. Motor make, and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches, and bore.
   f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
   g. Number, make, and size of belts.

3. **Test Data (Indicated and Actual Values):**
   a. Total airflow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan rpm.
   d. Discharge static pressure in inches wg.
   e. Suction static pressure in inches wg.
H. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:
   a. System and air-handling-unit number.
   b. Location and zone.
   c. Traverse air temperature in deg F.
   d. Duct static pressure in inches wg.
   e. Duct size in inches.
   f. Duct area in sq. ft.
   g. Indicated air flow rate in cfm.
   h. Indicated velocity in fpm.
   i. Actual air flow rate in cfm.
   j. Actual average velocity in fpm.
   k. Barometric pressure in psig.

I. Air-Terminal-Device Reports:

1. Unit Data:
   a. System and air-handling unit identification.
   b. Location and zone.
   c. Apparatus used for test.
   d. Area served.
   e. Make.
   f. Number from system diagram.
   g. Type and model number.
   h. Size.
   i. Effective area in sq. ft.

2. Test Data (Indicated and Actual Values):
   a. Air flow rate in cfm.
   b. Air velocity in fpm.
   c. Preliminary air flow rate as needed in cfm.
   d. Preliminary velocity as needed in fpm.
   e. Final air flow rate in cfm.
   f. Final velocity in fpm.
   g. Space temperature in deg F.

J. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:
   a. System and air-handling-unit identification.
   b. Location and zone.
   c. Room or riser served.
   d. Coil make and size.
   e. Flowmeter type.
2. Test Data (Indicated and Actual Values):
   a. Air flow rate in cfm.
   b. Entering-water temperature in deg F.
   c. Leaving-water temperature in deg F.
   d. Water pressure drop in feet of head or psig.
   e. Entering-air temperature in deg F.
   f. Leaving-air temperature in deg F.

K. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:
   a. Unit identification.
   b. Location.
   c. Service.
   d. Make and size.
   e. Model number and serial number.
   f. Water flow rate in gpm.
   g. Water pressure differential in feet of head or psig.
   h. Required net positive suction head in feet of head or psig.
   i. Pump rpm.
   j. Impeller diameter in inches.
   k. Motor make and frame size.
   l. Motor horsepower and rpm.
   m. Voltage at each connection.
   n. Amperage for each phase.
   o. Full-load amperage and service factor.
   p. Seal type.

2. Test Data (Indicated and Actual Values):
   a. Static head in feet of head or psig.
   b. Pump shutoff pressure in feet of head or psig.
   c. Actual impeller size in inches.
   d. Full-open flow rate in gpm.
   e. Full-open pressure in feet of head or psig.
   f. Final discharge pressure in feet of head or psig.
   g. Final suction pressure in feet of head or psig.
   h. Final total pressure in feet of head or psig.
   i. Final water flow rate in gpm.
   j. Voltage at each connection.
   k. Amperage for each phase.

L. Instrument Calibration Reports:

1. Report Data:
   a. Instrument type and make.
3.15 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.

2. Check the following for each system:

   a. Measure airflow of at least 10 percent of air outlets.
   b. Measure water flow of at least 5 percent of terminals.
   c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
   d. Verify that balancing devices are marked with final balance position.
   e. Note deviations from the Contract Documents in the final report.

B. Final Inspection:

1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Owner or Construction Manager.

2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Owner or Construction Manager.

3. Owner or Construction Manager shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.

2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the
D. Prepare test and inspection reports.

3.16 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593
SECTION 230700 - HVAC INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Insulation Materials:
   a. Mineral fiber.
   b. Flexible Elastomeric

2. Fire-rated insulation systems.
3. Adhesives.
5. Lagging adhesives.
7. Factory-applied jackets.
8. Field-applied jackets.
10. Securements.
11. Corner angles.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity,
   thickness, and jackets (both factory and field applied, if any).

B. Shop Drawings:

1. Detail application of protective shields, saddles, and inserts at hangers for
each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of
   insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and
   specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections,
   and access panels.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.
8. Detail field application for each equipment type.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.

1. Sample Sizes:
   b. Sheet Form Insulation Materials: 12 inches square.
   d. Sheet Jacket Materials: 12 inches square.
   e. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

D. Qualification Data: For qualified Installer.

E. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

F. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.
1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified.

B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290,
Type II with factory-applied vinyl jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide the following:
   a. CertainTeed Corp.; Duct Wrap.
   b. Johns Manville; Microlite.
   c. Knauf Insulation; Duct Wrap.
   d. Manson Insulation Inc.; Alley Wrap.
   e. Owens Corning; All-Service Duct Wrap.
   f. Or Approved Substitute.

G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied ASJ. For equipment applications, provide insulation without factory-applied jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide the following:
   a. CertainTeed Corp.; Commercial Board.
   b. Fibrex Insulations Inc.; FBX.
   c. Johns Manville; 800 Series Spin-Glas.
   d. Knauf Insulation; Insulation Board.
   e. Manson Insulation Inc.; AK Board.
   f. Owens Corning; Fiberglas 700 Series.
   g. Or Approved Substitute.

H. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements, provide the following:
   a. Fibrex Insulations Inc.; Coreplus 1200.
   b. Johns Manville; Micro-Lok.
   c. Knauf Insulation; 1000 Pipe Insulation.
   d. Manson Insulation Inc.; Alley-K.
   e. Owens Corning; Fiberglas Pipe Insulation.
   f. Or Approved Substitute.

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

I. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x
deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide the following:

   a. CertainTeed Corp.; CrimpWrap.
   b. Johns Manville; MicroFlex.
   c. Knauf Insulation; Pipe and Tank Insulation.
   d. Manson Insulation Inc.; AK Flex.
   e. Owens Corning; Fiberglas Pipe and Tank Insulation.
   f. Or Approved Substitute.

2.2 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by a NRTL acceptable to authority having jurisdiction. Multiple layers may be required to provide 2 hour fire rating. Fire-rated insulation shall be installed by a certified installer approved and trained by the manufacturer of the product being installed.

1. Products: Subject to compliance with requirements, provide the following:

   a. CertainTeed Corp.; FlameChek.
   b. Johns Manville; Firetemp Wrap.
   d. Thermal Ceramics; FireMaster Duct Wrap.
   e. 3M; Fire Barrier Wrap Products.
   f. Unifrax Corporation; FyreWrap.
   g. Vesuvius; PYROSCAT FP FASTR Duct Wrap.
   h. Or Approved Substitute.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

   B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, provide the following:

   a. Aeroflex USA Inc.; Aeroseal.
   b. Armacell LCC; 520 Adhesive.
   c. Foster Products Corporation, H. B. Fuller Company; 85-75.
   d. RBX Corporation; Rubatex Contact Adhesive.
   e. Or Approved Substitute.
C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Childers Products, Division of ITW; CP-82.
      c. ITW TACC, Division of Illinois Tool Works; S-90/80.
      d. Marathon Industries, Inc.; 225.
      e. Mon-Eco Industries, Inc.; 22-25.
      f. Or Approved Substitute.

D. ASJ Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Childers Products, Division of ITW; CP-82.
      c. ITW TACC, Division of Illinois Tool Works; S-90/80.
      d. Marathon Industries, Inc.; 225.
      e. Mon-Eco Industries, Inc.; 22-25.
      f. Or Approved Substitute.

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.

B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Products, Division of ITW; CP-35.
      b. Foster Products Corporation, H. B. Fuller Company; 30-90.
      c. ITW TACC, Division of Illinois Tool Works; CB-50.
      d. Marathon Industries, Inc.; 590.
      e. Mon-Eco Industries, Inc.; 55-40.
      f. Vimasco Corporation; 749.
      g. Or Approved Substitute.

2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
5. Color: Gray
2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. Products: Subject to compliance with requirements, provide the following:
   a. Childers Products, Division of ITW; CP-52.
   b. Foster Products Corporation, H. B. Fuller Company; 81-42.
   c. Marathon Industries, Inc.; 130.
   d. Mon-Eco Industries, Inc.; 11-30.
   e. Vimasco Corporation; 136.
   f. Or Approved Substitute.

2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.

3. Service Temperature Range: Minus 50 to plus 180 deg F.


2.6 SEALANTS

A. ASJ Flashing Sealants:

1. Products: Subject to compliance with requirements, provide the following:
   a. Childers Products, Division of ITW; CP-76.
   b. Or Approved Substitute.

2. Materials shall be compatible with insulation materials, jackets, and substrates.

3. Fire- and water-resistant, flexible, elastomeric sealant.

4. Service Temperature Range: Minus 40 to plus 250 deg F.


2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.

2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. Metal Jacket:

1. Products: Subject to compliance with requirements, provide the following:

   a. Childers Products, Division of ITW; Metal Jacketing Systems.
   b. PABCO Metals Corporation; Surefit.
   c. RPR Products, Inc.; Insul-Mate.
   d. Or Approved Substitute.


   a. Factory cut and rolled to size.
   b. Finish and thickness are indicated in field-applied jacket schedules.
   d. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
   e. Factory-Fabricated Fitting Covers:

      1) Same material, finish, and thickness as jacket.
      2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      3) Tee covers.
      4) Flange and union covers.
      5) End caps.
      6) Beveled collars.
      7) Valve covers.
      8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

   1. Products: Subject to compliance with requirements, provide the following:

      a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
      b. Compac Corp.; 104 and 105.
      c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
      d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
e. Or Approved Substitute.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

2.10 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, provide the following:
   a. Childers Products; Bands.
   b. PABCO Metals Corporation; Bands.
   c. RPR Products, Inc.; Bands.
   d. Or Approved Substitute.

2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal.

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Products: Subject to compliance with requirements, provide the following:
      1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.
      2) GEMCO; Perforated Base.
      3) Midwest Fasteners, Inc.; Spindle.
      4) Or Approved Substitute.
   b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   c. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
   d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to
substrates indicated without damaging insulation, hangers, and substrates.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

   a. Products: Subject to compliance with requirements, provide the following:

      1) AGM Industries, Inc.; RC-150.
      2) GEMCO; R-150.
      3) Midwest Fasteners, Inc.; WA-150.
      4) Nelson Stud Welding; Speed Clips.
      5) Or Approved Substitute.

   b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch wide, stainless steel or Monel.

D. Wire: 0.080-inch nickel-copper alloy.

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

      b. Childers Products.
      c. PABCO Metals Corporation.
      d. RPR Products, Inc.
      e. Or Approved Substitute.

2.11 CORNER ANGLES

   A. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105 or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 EXAMINATION

   A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.
J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
   a. For below ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above ambient services, do not install insulation to the following:
1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

C. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements for firestopping and fire-resistant joint sealers.

D. Insulation Installation at Floor Penetrations:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Pipe: Install insulation continuously through floor penetrations.
3. Seal penetrations through fire-rated assemblies. Comply with requirements as specified.

3.5 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

A. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
1. Apply adhesives according to manufacturer’s recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.

2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.

3. Protect exposed corners with secured corner angles.

4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
   a. Do not weld anchor pins to ASME-labeled pressure vessels.
   b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
   c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
   d. Do not overcompress insulation during installation.
   e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
   f. Impale insulation over anchor pins and attach speed washers.
   g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.

6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.

7. Stagger joints between insulation layers at least 3 inches.

8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.

9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.

10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at
corners. Install 3/8-inch-diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.

2. Fabricate boxes from galvanized steel, at least 0.040 inch thick.

3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.6 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.

2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.

3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.

4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

9. Label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.7 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
   4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install preformed sections of same material as straight segments of pipe insulation when available.
   2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed sections of same material as straight segments of pipe insulation when available.
   2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
   3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   4. Install insulation to flanges as specified for flange insulation application.

E. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
   1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
   2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not overcompress insulation during installation.
   e. Impale insulation over pins and attach speed washers.
   f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.

6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

   F. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.

2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.

   b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

   d. Do not overcompress insulation during installation.

   e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.
3.8 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

   1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
   2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
   3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.9 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies as specified.

3.10 FINISHES

A. Duct, Equipment, and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified.

   1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.


B. Color: Final color as selected by Engineer. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless-steel jackets.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.
B. Tests and Inspections:

1. Inspect ductwork, randomly selected by Engineer, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

2. Inspect field-insulated equipment, randomly selected by Engineer, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

3. Inspect pipe, fittings, strainers, and valves, randomly selected by Engineer, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.12 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in nonconditioned space.
4. Indoor, exposed return located in nonconditioned space.
5. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
6. Indoor, exposed, Type I, commercial, kitchen hood exhaust.
7. Indoor, concealed oven and warewash exhaust.
8. Indoor, exposed oven and warewash exhaust.
9. Outdoor, concealed supply and return (2” R8.0).
10. Outdoor, exposed supply and return (2” R8.0).

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
5. Flexible connectors.
7. Factory-insulated access panels and doors.
3.13 DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, supply-air duct and plenum insulation shall be the following:
   1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

B. Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket; thickness as required to achieve 2-hour fire rating.

C. Exposed or outdoor, supply-air duct insulation or return air/outside air plenum insulation shall be the following:
   1. Internally Lined. Refer to Section 233113 “Metal Ducts” for internal duct liner specifications.

3.14 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.

C. Steam-to-hot-water converter insulation shall be the following:

D. Chilled and Heating Hot Water pump insulation shall be the following:
   1. Mineral-Fiber Board: 1.5 inches thick and 3-lb/cu. ft. nominal density.

E. Heating-hot-water expansion/compression tank insulation shall be the following:

F. Steam condensate tank and receiver insulation shall be the following:

3.15 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor’s option.
B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.16 PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:
   1. All Pipe Sizes: Insulation shall be one of the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

B. Chilled Water Supply and Return:
   1. Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe, Type I: 1.5 inches thick.

C. Heating-Hot-Water Supply and Return, 200 Deg F and below:
   1. NPS 12 and Smaller: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.

D. Steam and Steam Condensate Piping:
   1. 4 Inch and Smaller: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe, Type I or II: 2 inches thick.

3.17 FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
   1. Aluminum, Smooth: 0.020 inch thick.

D. Outdoor Piping, Exposed:
1. Aluminum, Smooth: 0.020 inch thick.

END OF SECTION 230700
SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section includes insulating the following HVAC piping systems:
   1. Chilled-water piping, indoors and outdoors.
   2. Heating hot-water piping, indoors and outdoors.

1.3 SUBMITTALS
A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).
B. Qualification Data: For qualified Installer.
C. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
D. Field quality-control reports.

1.4 QUALITY ASSURANCE
A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

1.5 DELIVERY, STORAGE, AND HANDLING
A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.
1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified.

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Johns Manville; Micro-Lok.
   b. Manson Insulation Inc.; Alley-K.
   c. Owens Corning; Fiberglas Pipe Insulation.
   d. Or Approved Substitute.
2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements as specified.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 225.
   d. Mon-Eco Industries, Inc.; 22-25.
   e. Or Approved Substitute.

2. One or both subparagraphs below may be required to comply with Project requirements or authorities


1. Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 225.
   d. Mon-Eco Industries, Inc.; 22-25.
   e. Or Approved Substitute.

D. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Dow Corning Corporation; 739, Dow Silicone.
   c. Speedline Corporation; Polyco VP Adhesive.
   d. Or Approved Substitute.
2.3 MASTICS

A. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 501.
   d. Mon-Eco Industries, Inc.; 55-10.
   e. Or Approved Substitute.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
3. Service Temperature Range: 0 to 180 deg F.

B. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 570.
   d. Or Approved Substitute.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.

2.4 LAGGING ADHESIVES

1. Products: Subject to compliance with requirements, provide one of the following:

c. Vimasco Corporation; 713 and 714.

d. Or Approved Substitute.

2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.

3. Service Temperature Range: 0 to plus 180 deg F.


2.5 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:

   b. Eagle Bridges - Marathon Industries; 405.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Or Approved Substitute.

2. Materials shall be compatible with insulation materials, jackets, and substrates.

3. Fire- and water-resistant, flexible, elastomeric sealant.

4. Service Temperature Range: Minus 40 to plus 250 deg F.

5. Color: Aluminum.

6. One or both subparagraphs below may be required to comply with Project requirements or authorities

B. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements provide one of the following:

   B. Or Approved Substitute.

2. Materials shall be compatible with insulation materials, jackets, and substrates.

3. Fire- and water-resistant, flexible, elastomeric sealant.

4. Service Temperature Range: Minus 40 to plus 250 deg F.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.

2.7 FIELD-APPLIED JACKETS

A. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Johns Manville; Zeston.
   c. Proto Corporation; LoSmoke.
   d. Or Approved Substitute.

2. Adhesive: As recommended by jacket material manufacturer.


4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
   a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

B. Metal Jacket:

1. Products: Subject to compliance with requirements, provide one of the following:
   b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
   c. RPR Products, Inc.; Insul-Mate.
   d. Or Approved Substitute.

   a. Sheet and roll stock ready for shop or field sizing or Factory cut and rolled to size.
   b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 3-mil thick, heat-bonded polyethylene and kraft paper.
d. Moisture Barrier for Outdoor Applications: 3-mil thick, heat-bonded polyethylene and kraft paper.
e. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide one of the following:

a. ABI, Ideal Tape Division; 428 AWF ASJ.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
c. Compac Corporation; 104 and 105.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
e. Or Approved Substitute.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Products: Subject to compliance with requirements, provide one of the following:

a. ABI, Ideal Tape Division; 370 White PVC tape.
b. Compac Corporation; 130.
c. Venture Tape; 1506 CW NS.
d. Or Approved Substitute.
2. Width: 2 inches.
3. Thickness: 6 mils.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. ABI, Ideal Tape Division; 488 AWF.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
   c. Compac Corporation; 120.
   d. Venture Tape; 3520 CW.
   e. Or Approved Substitute.

2. Width: 2 inches.
3. Thickness: 3.7 mils.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.9 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, provide one of the following:
   a. ITW Insulation Systems; Gerrard Strapping and Seals.
   b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
   c. Or Approved Substitute.

2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal or closed seal.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

C. Wire: 0.080-inch nickel-copper alloy.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
EMERGENCY GENERATOR AND DATA CENTER HVAC UPGRADES

- C & F Wire.
- Or Approved Substitute.

PART 3 - EXECUTION

3.1 EXAMINATION

A. No insulation new or existing to remain shall be allowed to contact moisture. All insulation must be protected against moisture throughout the project.

B. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.
3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
   4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.

3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
   
   a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer’s written instructions, to maintain vapor seal.

5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.
B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
   4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
   1. Comply with requirements for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:
   1. Pipe: Install insulation continuously through floor penetrations.
   2. Seal penetrations through fire-rated assemblies. Comply with requirements.

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
   1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
   2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
   3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
   2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
   3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
   4. Finish flange insulation same as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
   2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
   3. Finish fittings insulation same as pipe insulation.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.7 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
3.8 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:
   1. Install pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
   4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install mitered sections of pipe insulation.
   2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed valve covers manufactured of same material as pipe insulation when available.
   2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   3. Install insulation to flanges as specified for flange insulation application.
   4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.9 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
   4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive
as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.10 INSTALLATION OF PHENOLIC INSULATION

A. General Installation Requirements:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with 0.062-inch wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets with vapor retarders on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

C. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:
   1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

E. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
   2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   3. Install insulation to flanges as specified for flange insulation application.

3.11 INSTALLATION OF POLYISOCYANURATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3- and 9-o'clock positions on the pipe.
   2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
   3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.

C. Insulation Installation on Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed sections of polyisocyanurate insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.12 INSTALLATION OF POLYOLEFIN INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
1. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:
1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install mitered sections of polyolefin pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install cut sections of polyolefin pipe and sheet insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.13 INSTALLATION OF POLYSTYRENE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3- and 9-o'clock positions on the pipe.
   2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
   3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, and make thickness same as adjacent pipe insulation, not to exceed 1-1/2-inch.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed section of polystyrene insulation to valve body.
   2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   3. Install insulation to flanges as specified for flange insulation application.

3.14 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

E. Where PVDC jackets are indicated, install as follows:

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap factory-presized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
3. Continuous jacket can be spiral-wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch-circumference limit allows for 2-inch-overlap seal. Using the length of roll allows for longer sections of jacket to be installed.
at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.

5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.15 FINISHES

A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.


B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Engineer. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.16 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Engineer, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.
3.17 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.18 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:

1. All Pipe Sizes: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.

B. Chilled Water, above 40 Deg F:

1. NPS 12 and Smaller: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe, Type I 1-1/2 inches thick.

C. Heating-Hot-Water Supply and Return, 200 Deg F and Below:

1. NPS 12 and Smaller: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick.

3.19 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Chilled Water:

1. All Pipe Sizes: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inches thick.

B. Heating-Hot-Water Supply and Return, 200 Deg F and Below:

1. All Pipe Sizes: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
3.20 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor’s option.

C. Piping, Concealed:
   1. None.

D. Piping, Exposed:
   1. PVC 20 mils.

3.21 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor’s option.

C. Piping, Concealed:
   1. Aluminum, Corrugated 0.040 inch thick.

D. Piping, Exposed:
   1. Aluminum, Corrugated 0.040 inch thick.

END OF SECTION 230719
SECTION 230900 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

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

1.2 SUMMARY
   A. This section covers automatic temperature control systems and equipment.
   B. This project involves the installation of new Computrols CBAS system components including new TCP/IP Internet Ready DDC equipment, software, programming, controls, and field devices where needed. The new DDC panels shall be connected to an existing workstation located on the campus network.
   C. System must be nonproprietary with backwards capability for software and hardware.
   D. This section includes the furnishing and installation of controls and wiring for automatic controls, electric or pneumatic damper and valve actuators, air handling unit controls, boiler controls, pump controls, cooling tower controls, interlocks, starting circuits, and wiring to all power consuming devices.

1.3 DEFINITIONS
   A. DDC: Direct digital control.
   B. I/O: Input/output.
   C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
   D. MS/TP: Master slave/token passing.
   E. PC: Personal computer.
   F. PID: Proportional plus integral plus derivative.
   G. RTD: Resistance temperature detector.
1.4 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:

   a. Water Temperature: Plus or minus 1 deg F.
   b. Water Flow: Plus or minus 5 percent of full scale.
   c. Water Pressure: Plus or minus 2 percent of full scale.
   d. Space Temperature: Plus or minus 1 deg F.
   e. Ducted Air Temperature: Plus or minus 1 deg F.
   f. Outside Air Temperature: Plus or minus 2 deg F.
   g. Dew Point Temperature: Plus or minus 3 deg F.
   h. Temperature Differential: Plus or minus 0.25 deg F.
   i. Relative Humidity: Plus or minus 5 percent.
   j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
   k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
   l. Airflow (Terminal): Plus or minus 10 percent of full scale.
   m. Air Pressure (Space): Plus or minus 0.01-inch wg.
   n. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
   o. Carbon Monoxide: Plus or minus 5 percent of reading.
   p. Carbon Dioxide: Plus or minus 50 ppm.
   q. Electrical: Plus or minus 5 percent of reading.

1.5 SUBMITTALS

A. Product Data: Include manufacturer’s technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.

2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.

3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

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. Bill of materials of equipment indicating quantity, manufacturer, and model number.
2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
4. Details of control panel faces, including controls, instruments, and labeling.
5. Written description of sequence of operation.
6. Schedule of dampers including size, leakage, and flow characteristics.
7. Schedule of valves including flow characteristics.
8. DDC System Hardware:
   a. Wiring diagrams for control units with termination numbers.
   b. Schematic diagrams and floor plans for field sensors and control hardware.
   c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.

10. Controlled Systems:
   a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
   b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
   c. Written description of sequence of operation including schematic diagram.
   d. Points list.

C. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.
D. Qualification Data: For Installer and manufacturer.

E. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified, include the following:

   1. Maintenance instructions and lists of spare parts for each type of control.
   2. Interconnection wiring diagrams with identified and numbered system components and devices.
   4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
   5. Calibration records and list of set points.

H. Software and Firmware Operational Documentation: Include the following:

   1. Software operating and upgrade manuals.
   2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
   3. Device address list.
   4. Printout of software application and graphic screens.
   5. Software license required by and installed for DDC workstations and control systems.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation and programming of system components required for this Project.

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

C. Comply with ASHRAE 135 for DDC system components.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.
1.8 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment to achieve compatibility with equipment that interfaces with that system.

C. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

1.9 PROJECT CONDITIONS

A. Contractor shall visit the Project prior to bidding, and make a survey of existing control instruments. The contractor is responsible for all equipment, devices, and labor required to provide a complete and functional control system as required by the intent of the project documents.

1.10 EXTRA MATERIAL

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. Replacement Materials: One replacement diaphragm or relay mechanism for each unique valve motor, controller, thermostat, and positioning relay.

2. Maintenance Materials: One thermostat adjusting key(s).

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 CONTROL SYSTEM

A. Manufacturers:

1. Computrols, Inc. (Campus Standard, No Known Equal)
B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.

C. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

D. The control system install shall control and manage HVAC and shall be capable of control and management of lighting control systems under a single system computer and software package. Systems which require interfacing with additional or separate computers or systems shall not be acceptable.

E. The communication transmission network shall allow global sharing and exchange of information with other like controllers and field devices. The building automation system’s control logic programs and its associated controller’s logic programs shall be adjustable and changeable from the new building automation system head-end or any client connection via the World Wide Web. Systems that require a separate Internet gateway or separate utility program are not acceptable. All components of the total system shall be Internet ready and of the electronic DDC type.

F. All new DDC controllers must have the ability to communicate to other controllers (peer-to-peer) and to the building automation software using standard TCP/IP communication.

G. Control system shall include the following:

1. Comply with fire alarm system as specified.

2.3 DDC EQUIPMENT

A. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.

2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

   a. Global communications.
   b. Discrete/digital, analog, and pulse I/O.
   c. Monitoring, controlling, or addressing data points.
d. Software applications, scheduling, and alarm processing.
e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Standard Application Programs:
   a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.
   b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
   c. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
   d. Remote communications.
   e. Maintenance management.
   f. Units of Measure: Inch-pound and SI (metric).

4. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

5. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

B. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.
   1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
   2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
      a. Global communications.
      b. Discrete/digital, analog, and pulse I/O.
      c. Monitoring, controlling, or addressing data points.

3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

4. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

C. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.
   1. Binary Inputs: Allow monitoring of on-off signals without external power.
   2. Analog Inputs: Allow monitoring of low-voltage (0-10 V-dc), current (4-20 mA), or resistance signals.
3. Binary Outputs: 24 V-dc, 100 mA output
4. Analog Outputs: Provide modulating signal, low voltage (0-10 V-dc).
5. Universal I/Os: Provide software selectable binary or analog outputs.

D. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV-dc maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

E. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V-ac.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

F. Communication Ports: Controllers shall have at a minimum the following ports:

1. 10 MB CAT 5 TCP/IP port
2. 1 MB multi-drop port for #18 twisted pair cabling
3. RS-485 port non-polarity conscious up to 38.4 KBAUD
4. Software selectable RS-485 / RS-232 port

G. Software

1. Each controller shall be capable of networking with the building automation system without the use of separate utility software.
2. Global points may be shared across the network (peer-to-peer). Global points, or any shared network information, shall not include scheduling functions.
3. Closed loop control functions shall include automatic PID tuning for proportional, proportional plus integral, proportional plus integral plus derivative, incremental, and floating control.

H. Hardware

1. All DDC Controllers shall have a minimum 386 MHz 32 bit microprocessor.
2. The controller shall be a separate entity such that it may be detached from its respective terminal strip without removing any field wiring from the terminal strip.
3. All DDC Controllers shall be guaranteed under normal use for the life of the building.
I. Environmental

1. Controllers and associated control panel devices shall function properly between 32 and 122 deg F.
2. Controllers and associated control panel devices shall function properly between 0 and 95 percent relative humidity (noncondensing).
3. Storage conditions for the controller shall be between minus 4 and 140 deg F.
4. Storage conditions for the controller shall be between 0 and 95 percent relative humidity (noncondensing).

2.4 UNITARY CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.

1. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.
2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.
3. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.
4. Enclosure: Dustproof rated for operation at 32 to 120 deg F.
5. Enclosure: Waterproof rated for operation at 40 to 150 deg F.

2.5 ALARM PANELS

A. Unitized cabinet with suitable brackets for wall or floor mounting. Fabricate of 0.06-inch-thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish. Provide common keying for all panels.

B. Indicating light for each alarm point, single horn, acknowledge switch, and test switch, mounted on hinged cover.

1. Alarm Condition: Indicating light flashes and horn sounds.
2. Acknowledge Switch: Horn is silent and indicating light is steady.
3. Second Alarm: Horn sounds and indicating light is steady.
4. Alarm Condition Cleared: System is reset and indicating light is extinguished.
2.6 ANALOG CONTROLLERS

A. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.

B. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 deg F, and single- or double-pole contacts.

C. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.

1. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.

D. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.

E. Receiver Controllers: Single- or multiple-input models with control-point adjustment, direct or reverse acting with mechanical set-point adjustment with locking device, proportional band adjustment, authority adjustment, and proportional control mode.

1. Remote-control-point adjustment shall be plus or minus 20 percent of sensor span, input signal of 3 to 13 psig.
2. Proportional band shall extend from 2 to 20 percent for 5 psig.
3. Authority shall be 20 to 200 percent.
4. Air-supply pressure of 18 psig, input signal of 3 to 15 psig, and output signal of zero to supply pressure.
5. Gages: 2-1/2 inches in diameter, 2.5 percent wide-scale accuracy, and range to match transmitter input or output pressure.

2.7 SYSTEM SOFTWARE

A. Software Platform:

1. The building automation software shall run on the Microsoft XP Professional operating system.
2. Interconnectivity between all workstations shall be achieved through the same protocol as the Internet, TCP/IP.

B. General features that must be provided:
1. The software shall provide a graphical user interface.
2. All points shall be programmable from a text view, hardware view, and graphics view.
3. English language point descriptors (systems which use point numbers with descriptors attached are not acceptable).
4. Event programming.
5. English “IF/THEN” logic programming (systems which use ladder type logic, graphic programming languages, or programs which must be compiled are not acceptable).
6. Example English logic programming statement:
   a. “IF COND WATER TEMP is less than 85 DEG
   b. AND CHILLER 1 is ON
   c. THEN ON COOLING TOWER FAN”
7. User-defined calculations.
8. Run-time calculations.
9. Customized password protection for individual features (systems which use levels of passwords are not acceptable). Software must provide protection from and rights to specific features for every operator.
10. Continuous historical data logging and charting for all points. Historical data shall be recorded after a pre-specified time passes or in the event of a pre-specified change in value.
11. Field hardware troubleshooting utility.
12. The downloading of any and all field panels shall be accomplished through the building automation system program at the head-end computer. Downloading of the field panels shall be accomplished while the building automation system program is running from the head-end computer. Systems which require exiting the building management program at the head-end computer to download DDC programs are unacceptable. Systems which require the use of separate utility programs to download DDC programs are unacceptable. Systems which require the use of laptop computers or other equipment other than the head-end computer to download DDC programs are unacceptable.
13. All DDC programs shall be stored in the individual controller’s memory. Systems with HVAC controllers which rely on the use of one or more network control units to store control logic programs are not considered stand-alone, and are deemed unacceptable. Systems with HVAC controllers that rely on pre-configured or “canned” control logic programs to operate as stand-alone are unacceptable.
14. Changes to existing setpoints or control logic shall be accomplished through the energy management system program at the head-end.

2.8 ENERGY MANAGEMENT FEATURES

A. PID loop control
   1. Automatic PID loop tuning:
a. Automatic PID loop tuning, to be initiated at any workstation. The tuning should be achieved through the use of sound mathematical principles, and not a rule-based inference engine.
b. All PID loops shall be tuned to produce a critically damped condition, automatic tunes are not allowed.
c. The automatic tuning must not require the supervision of an operator, and the software must be capable of tuning at least 10 PID loops simultaneously.
d. The operation of the building automation software should not be in any way impeded when tuning PID loops automatically, and it must be possible for the operator to continue the use of the software as normal during automatic tuning.
e. An operator can override the tuning at any point in time, in a well-defined and transparent manner.
f. Automatic PID tuning must not be the only means of setting the PID parameters. A manual tuning method must also be provided that provides a graphical real-time feedback of the system’s response.

2. All PID loops have the capacity for gain scheduling; i.e. the controller parameters change automatically based on measured operating conditions.

3. PID loop performance tracking must be provided for at least one week, storing information pertinent to fault diagnosis, including standard deviation and average absolute error.

B. Time of day scheduling.

C. Holiday scheduling.

D. Overtime scheduling.

E. Discharge/supply temperature reset.

F. Night setback/morning warm-up.

G. Automatic computer restart after power failure. Software shall provide equipment start-up queue with delay to minimize start-up electrical demand.

H. All Analog In/Out and Digital In/Out points shall be in 10 min intervals for a minimum period of no less than 72 hours set as a First-In, First-Out configuration. Trends shall be printed and arranged in columnar form and submitted at the acceptance of the control system.

2.9 GRAPHICS

A. Must support VGA and Super VGA graphic resolutions, at least 1024 by 768 pixels with at least 256 colors.

B. Must support scanned and video captured images.
C. All graphics must be dynamically updated.

D. All point statuses, colors, and graphic objects must be user-definable.

E. Definable graphic objects must include:
   1. Live status displays.
   2. Color fills for areas/zones.
   3. Variable bar graphs for analog data.
   4. Regions to link to other graphics.

2.10 INFORMATION SORTING

A. The software must sort points by:
   1. Units (degrees F, % Open, Dry, On, etc.) such that any point type with the
      selected unit type will populate the list.
   2. Alarms, Alarm Condition (in alarm, disabled, normal, etc.).
   3. User-defined groups.
   4. Attributes; including if the point is part of a PID, has a schedule, or has
      logic programmed in it.

2.11 REPORTS

1. System activity tracking-commands, edits, alarms, etc.
2. Historical data reports-recall past point statuses.
3. Custom scheduled reports-user definable for weekly, monthly, and yearly
   averages, totals, degree-days, etc.
4. Hardware report-logically organized summary of field equipment, which
   may be printed in panel-specific sheets suitable for mounting on a panel
   enclosure.
6. All reports must have the capability to be routed to the screen for quick
   browsing, to a configured printer, or to a file.
7. Reports must have the capability to be exported as ASCII delimited fields
   and for use with various other programs.
8. It must be possible to export reports directly to:
   a. The World-Wide-Web (i.e. HTML).
   b. Microsoft Excel.
   c. Microsoft Word.

9. MATERIALS

   a. New space mounted temperature sensors:
      1) Sensing element – 10,000 ohm TYPE III thermistor.
      2) Accuracy – Plus or minus 0.36 deg F.
      3) Range - 35 to 140 deg F.
4) Temperature response - Negative temperature coefficient.
5) Stability - 0.24 deg F over 5 years.
6) Connections – Screw terminals.

b. New space mounted temperature/humidity sensors:

1) Specifications for humidity element:
   a) Sensing element – Monolithic IC capacitive sensor.
   b) Accuracy - Plus or minus 3 percent RH at 77 deg F, 5-95 percent RH including hysteresis, linearity and repeatability.
   c) Range – 0-100 percent RH.
   d) Hysteresis – Less than 1 percent.
   e) Long term stability – Less than 1 percent drift per year.
   f) Output – Two-wire, loop powered, 4-20 mA = 0-100 percent RH linear.
   g) Supply voltage – 18-35 V-dc.
   h) Operating range – 0-100 percent RH, 4-20 mA.
   i) Operating temperature - 32 to 122 deg F.
   j) Connections – Screw terminals marked “+” and “-”.

2) Specifications for temperature element:
   a) Sensing element – 10,000 ohm TYPE III thermistor.
   b) Accuracy – Plus or minus 0.36 deg F.
   c) Range – 35 to 140 deg F.
   d) Temperature response - Negative temperature coefficient.
   e) Stability - 0.24 deg F over 5 years.
   f) Connections – Screw terminals.

c. New duct mounted temperature sensors:

1) Sensing element - 10,000 ohm thermistor with 306 stainless steel probe.
2) Accuracy – Plus or minus 0.36 deg F.
3) Range – 35 to 140 deg F.
4) Temperature response - Negative temperature coefficient
5) Stability - 0.24 deg F over 5 years.
6) Connections – 8 feet of 22 AWG pigtails pre-stripped inside of factory installed metallic handibox.

d. New duct mounted humidity/temperature sensors:

1) Specifications for humidity element:
   a) Transmitter output and calibration – Two-wire, 4-20 mA = 0-100 percent RH.
   b) Sensing element – Monolithic IC capacitive sensor.
c) Accuracy – Plus or minus 2 percent RH at 77 deg F, 5-95 percent RH including hysteresis, linearity and repeatability.
d) Range – 0-100 percent RH.
e) Hysteresis – Less than 1 percent.
f) Long term stability – Less than 1 percent drift per year.
g) Output – Two-wire, loop powered, 4-20 mA = 0-100 percent RH linear.
h) Supply voltage – 18-35 V-dc.
i) Operating range – 0-100 percent RH, 4-20 mA.
j) Operating temperature - Minus 20 to 185 deg F.
k) Connections – Screw terminals marked “+” and “-”.

2) Specifications for temperature element:

a) Transmitter range – 0 to 100 deg F.
b) Sensing element – Platinum 1000 ohm RTD.
c) Accuracy – Plus or minus 0.5 deg F.
d) Output – 4 to 20 mA over calibrated range.

e. New digital and analog current sensors:

1) Amperage rating - calibrate each unit to motor full load amp rating.
2) Isolation - 600 V.
3) Frequency range - 60 Hz nominal.
4) Accuracy - 2.0 percent all scales.
5) Temperature range – 5 to 140 deg F.
6) Output – dry contact or 0 – 5 V-dc.

f. New control valves:

1) All control valves shall be fully proportioning of the ball type design.
2) Two way valves (1/2 inch to 3 inches) and three way valves (1/2 inch to 2 inches) shall be industrial quality with bronze bodies and female NPT threads. Valve bodies may also be stainless steel or carbon steel with operating pressures up to 1000 psi (two way valves) or 800 psi (three way valves).
3) All valves shall have blowout proof stem design, glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 600 psi rating (two way valves) or 400 psi rating (three way valves). The stem packing gland screw shall be adjustable for wear. Valves suitable for water or low-pressure steam shall incorporate an anti-condensation cap thermal break in the stem design.
4) Water valves shall have the standard chromium plated bronze ball and brass stem and shall be rated at a maximum of 600
psi WOG* (two way valves) or 400 psi WOG* (three way valves) valve body rating.

5) Low pressure steam valves (0 to 15 psi) shall have a three piece 316 Stainless Steel ball and stem and shall be rated at a maximum of 600 psi valve body rating. Valves shall be installed in the piping at a 30 to 45 degree angle from vertical. Valve and linkage shall be insulated.

6) Medium and high-pressure steam valves (15 to 150 psi) shall have a three-piece 316 Stainless Steel body, ball, and stem and shall be rated at a maximum of 1000 psi valve body rating. Valves shall be provided with a heat detection bracket and shall be installed in the piping at a 30 to 45 degree angle from vertical. Valve and linkage shall be insulated.

7) Valves for corrosive environments shall have 316 Stainless Steel body, ball, and stem and shall be rated at a maximum of 1000 psi (two way valves) or 800 psi (three way valves) valve body rating.

8) Optional ball valve insulation casing available for all valve assemblies (except the three piece design for medium and high pressure steam). The casing shall be rated for minus 40 to 220 deg F. The casing shall be installed inside the open area in the valve bracket and shall prevent condensation from reaching the actuator.

9) The two-way flanged ball valves shall have a cast iron body and a stainless steel ball and stem. The maximum working pressure shall be 200 psi.

10) The three-way flanged ball valves shall have a carbon steel body and a stainless steel ball and stem. The maximum working pressure shall be 275 psi.

11) Shall be sized by the control equipment contractor for a maximum pressure drop of 5 psi or as specified on the contract drawings. All sizing calculations must incorporate adjustments to the calculated Cv to reflect the Piping Geometry Factor (FP) and shall be listed on the valve schedule. All control valves shall be suitable for the pressure conditions as noted for the piping system in which installed and shall close against the differential pressures involved.

12) 2-way valve action - chilled water: normally closed, hot water: normally open, steam: normally closed

13) 3-way valve action – chilled water: piped to bypass the coil, hot water: piped to flow through the coil

g. Control valve actuator specifications:

1) Actuators shall be fully modulating, floating (tri-state), two position, spring return, or 0-135 ohm slide wire as indicated in the control sequence. Fail safe where specified shall require either mechanical spring return, or battery back up located

* WOG-(Water-Oil-Gas) This rating is based on paragraph UG101 of the ASME Boiler and Pressure Vessel Code.
near the building automation control panel for ease of maintenance. Upon loss of power, fail-safe valve assemblies shall fail either Normally Open (N.O.) or Normally Closed (N.C.). Non-fail safe valve assemblies shall remain in last position upon loss of power. Note: Battery back-up units or storage capacitor type units contained within the individual actuators are not acceptable unless using Industrial actuators.

2) Modulating valves shall be positive positioning, responding to a 2-10 V-dc, 4-20 mA signal (with addition of a 500 ohm resistor), or pulse width signal. There shall be a visual valve position indicator and an actuator generated 2-10 V-dc valve position output signal for electronic feedback to the control panel. Feedback signal shall be available to provide a DDC input signal or to drive a second "slave" or tandem actuator. The feedback signal shall be independent of the input signal. The actuator shall have the capability of adding auxiliary switches or feedback potentiometer if required. Powering shall be 120 V-ac, 24 V-ac, or 24 V-dc, and power consumption shall not exceed 12 watts. For industrial type actuators, the power consumption shall not exceed 85 watts. Three-foot cables shall be provided for easy installation to an electrical junction box.

3) The actuator(s) shall provide minimum torque required for proper valve close off, with an approximate running time of 2 minutes for full rotation for non-industrial type actuators. The actuator shall be designed with current limiting motor protection (end of travel switches are not acceptable). A release button on the actuator shall be provided to allow for manual override, except with utilizing spring return actuators. Spring return actuators capable of manual override shall be provided with an override key. Tandem mounted spring return actuators shall be provided with a shaft to enable override of both actuators with a single override key. All actuators shall have an external direction of rotation switch.

4) All assemblies shall have a minimum resolution of 80 to 1 and a turndown exceeding 597 to 1. All actuators shall be UL listed. The manufacturer shall warranty all assemblies for a period of 2 years from the date of installation not exceeding 30 months from date of original shipment.

5) The valve manufacturer shall provide valve identification on the model number label. The tag may contain up to 30 characters. Tags shall be documented on the approved, submitted schedule.

6) Control valves shall be provided by Delta Control Products, Inc. Weston, FL, Phoenix, AX, and Chicago, IL.

h. New control damper actuators:

1) Control damper actuators shall be electronic direct-coupled types, which require no crank arm and linkage.
2) Actuators shall be UL listed and CSA certified and be manufactured under ISO 9001 International Quality Control Standards.

3) Actuators shall have a reversing switch and gear disengagement button on the cover.

4) Actuators shall use a brushless DC motor and be protected from overload at all angles of rotation.

5) Run time shall be consistent and independent of torque.

6) The actuator must provide proportional damper control in response to a 2-10 V-dc control input from the DDC controller for any outside air damper, return air damper, or exhaust air damper.

7) For smoke dampers, combination fire/smoke dampers, and other two position dampers the actuator must be of the on/off spring return type and accept either a 120 V-ac or 24 V-ac signal.

i. New airflow measuring devices:

1) Sensor must be able to measure high or low velocity airflow in duct systems an air handlers.

2) The design of the sensor must amplify the velocity pressure by a factor of three, to allow high accuracy measurements of low air velocities.

3) New differential pressure transmitters.

4) The transmitter must have the capability to convert very low-pressure signals into a precise, drift-free and repeatable analog output.

5) The transmitter must incorporate a 100% solid-state piezoresistive-sensing element, which is immune to mounting orientation or vibration.

6) The unit must be fully temperature compensated and provide a stable output over a wide temperature band.

7) The output of the transmitter shall be 0-10 V-dc, have a pressure range of 0 to 3 inch WCD, and accept a supply voltage of 24 V-ac.

j. New DDC control cabinets:

1) The control cabinets must be UL #E 130598. Cabinets shall have the following features:

   a) Can be mounted with door hinged on left of right side.
   b) Removable door.
   c) Furnished with a key lock.
   d) NEMA 3 rating.

k. New control transformers:

1) Multi-tap primary connections for 120 V-ac, 208 V-ac, 240 V-ac, and 480 V-ac.
2) 24 V-ac secondary voltage output.
3) 100 VA rating for DDC controller power.
4) 40 VA rating for field device power.
6) Foot mount provisions.
7) UL # E3210.
8) Insulation class – 356 deg F.
9) Temperature rise – 144 deg F.

l. New thermostats: Room type shall have a blank cover and concealed means of adjustment. Remote element type shall have and accessible adjustment knob. Provide separable wells for elements in liquids and extended necks for wells in insulated pipe.

1) Low limit safeties: Elements shall respond to the lowest temperature to which any 12 inch segment is exposed; minimum length 8 feet.
2) Averaging switches: For use in coil discharge and mixed air locations.

m. New gradual switches: Potentiometer type with accessible means of adjustment.

n. New relays, transformers, and fusestats: Provide as needed.

o. New PE switches: Dust free sealed type, mercury or micro, with high and low limits independently adjustable over the entire range. Adjustability is not required for 2-position interlock for nonmodulating signals.

p. New pneumatic actuators: Diaphragm or piston type, sized as recommended by the manufacturer to control the driven apparatus smoothly. Modulating valve and damper actuators in control sequences involving 2 or more devices or stages shall be provided with a positioning device.

q. New manual push buttons: Flush mounted, in NEMA 1 enclosure with pilot light.

r. New firestats: Manual reset, remote bulb type in hazardous locations, UL approved, set at 135 deg F. in return air, and 50 deg F. above maximum operating temperatures in other locations.

2.12 CONTROL CABLE

A. Comply with electronic and fiber-optic cables for control wiring as specified.

2.13 EXISTING DDC SYSTEM MODIFICATIONS

A. Remove and replace existing DDC components where such components are shown in control drawings or noted to be replaced in specifications, unless specifically noted as "Existing to Remain."
B. Integrate new controls with the campus legacy systems (Computrol and Wonderware).

2.14 CONTROL AND INSTRUMENTATION ALLOWANCE

A. Contractor shall include in bid all material, associated items such as conduit, cabling, attachments, programming, anchorages, and labor, for the complete installation of the following at a location to be determined during the course of the project. At the completion of the project, contractor shall provide credit to owner for all unused items:

1. (10) Differential Pressure Transmitters.
2. (10) Temperature Transmitters.
3. (5) Control Valves and Valve Actuators.
4. (5) Control Dampers and Damper Actuators.
5. (10) Carbon Dioxide Sensors.

B. All existing and new DDC panels shall have a minimum of 15 percent of their I/O points reserved for future connections. Provide additional DDC control panels as necessary to meet minimum spare capacity requirement.

C. Contractor shall include in bid all labor and material required to provide (1) new 120 V-ac dedicated circuit for each new DDC panel provided.

D. Contractor shall include in bid all labor and material required to provide (1) new network drop from the nearest IDF to each new control panel.

E. Contractor shall include in bid all labor and material required to provide (1) new network drop in each room where DDC panel(s) is/are located to allow for M&O staff access to network without disconnecting the DDC panel.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that power supply is available to control units and operator workstation.

3.2 INSTALLATION

A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Connect and configure equipment and software to achieve sequence of operation specified.
C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above the floor.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

D. Install guards on thermostats in the following locations:

1. Entrances.
2. Public areas.
3. Where indicated.

E. Install automatic dampers as specified.

F. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

G. Install labels and nameplates to identify control components as specified.

H. Install hydronic instrument wells, valves, and other accessories as specified.

I. Install duct volume-control dampers as specified.

J. Install electronic and fiber-optic cables as specified.

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets as specified.

B. Install building wire and cable as specified.

C. Install signal and communication cable as specified.

1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
2. Install exposed cable in raceway.
3. Install concealed cable in raceway.
4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
4. Pressure test control air piping at 30 psig or 1.5 times the operating pressure for 24 hours, with maximum 5-psig loss.
5. Pressure test high-pressure control air piping at 150 psig and low-pressure control air piping at 30 psig for 2 hours, with maximum 1-psig loss.
6. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
7. Test each point through its full operating range to verify that safety and operating control set points are as required.
8. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
9. Test each system for compliance with sequence of operation.
10. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check installation of air supply for each instrument.
6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
8. Check temperature instruments and material and length of sensing elements.
9. Check control valves. Verify that they are in correct direction.
10. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.

11. Check DDC system as follows:
   a. Verify that DDC controller power supply is from emergency power supply, if applicable.
   b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
   c. Verify that spare I/O capacity has been provided.
   d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.5 ADJUSTING

A. Tune all PI and PID loops to produce a critically damped condition.

B. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer’s written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:
   a. Check analog inputs at 0, 50, and 100 percent of span.
   b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
   c. Check digital inputs using jumper wire.
   d. Check digital outputs using ohmmeter to test for contact making or breaking.
   e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

5. Flow:
   a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
   b. Manually operate flow switches to verify that they make or break contact.

6. Pressure:
   a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

7. Temperature:
   a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
   b. Calibrate temperature switches to make or break contacts.

8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.

9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.

10. Provide diagnostic and test instruments for calibration and adjustment of system.

11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

C. Adjust initial temperature and humidity set points.

D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls.
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.
5. Pressure regulators.
7. Mechanical sleeve seals.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.4 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.
2. Service Regulators: 100 psig minimum unless otherwise indicated.
3. Minimum Operating Pressure of Service Meter: 5 psig.

B. Natural-Gas System Pressure within Buildings: 0.5 psig or less.
C. Delegated Design: Design restraints and anchors for natural-gas piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.5 SUBMITTALS

A. Product Data: For each type of the following:
   1. Piping specialties.
   2. Corrugated, stainless-steel tubing with associated components.
   3. Valves: Include pressure rating, capacity, settings, and electrical connection data of selected models.
   4. Pressure regulators: Indicate pressure ratings and capacities.
   5. Service meters: Indicate pressure ratings and capacities. Include supports.
   6. Dielectric fittings.
   7. Mechanical sleeve seals.
   8. Escutcheons.

B. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
   1. Shop Drawing Scale: 1/4 inch per foot.
   2. Detail mounting, supports, and valve arrangements for service meter assembly and pressure regulator assembly.

C. Delegated-Design Submittal: For natural-gas piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Detail fabrication and assembly of seismic restraints.
   2. Design Calculations: Calculate requirements for selecting seismic restraints.

D. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.

E. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.

F. Qualification Data: For qualified professional engineer.

G. Welding certificates.
H. Field quality-control reports.

I. Operation and Maintenance Data: For pressure regulators and service
meters to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel
according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according
to ASME Boiler and Pressure Vessel Code.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from
existing natural-gas piping according to requirements of authorities having
jurisdiction.

B. 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.

C. Store and handle pipes and tubes having factory-applied protective
coatings to avoid damaging coating, and protect from direct sunlight.

D. Protect stored PE pipes and valves from direct sunlight.

1.8 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing
utility locations. Contact utility-locating service for area where Project is
located.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas
service to facilities occupied by Owner or others unless permitted under
the following conditions and then only after arranging to provide purging
and startup of natural-gas supply according to requirements indicated:

1. Notify Engineer no fewer than 5 days in advance of proposed
   interruption of natural-gas service.

2. Do not proceed with interruption of natural-gas service without
   Engineer's written permission.

1.9 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment
   provided.
B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   b. End Connections: Threaded or butt welding to match pipe.
   c. Lapped Face: Not permitted underground.
   e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.

5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
   a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

B. PE Pipe: ASTM D 2513, SDR 11.

1. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
   b. Casing: Steel pipe complying with ASTM A 53/A 53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering.
c. Aboveground Portion: PE transition fitting.
d. Outlet shall be threaded or flanged or suitable for welded connection.
e. Tracer wire connection.
f. Ultraviolet shield.
g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

   a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet connected to steel pipe complying with ASTM A 53/A 53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
   b. Outlet shall be threaded or flanged or suitable for welded connection.
   c. Bridging sleeve over mechanical coupling.
   d. Factory-connected anode.
   e. Tracer wire connection.
   f. Ultraviolet shield.
   g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors:
   4. Operating-Pressure Rating: 0.5 psig.
   5. End Fittings: Zinc-coated steel.
   7. Maximum Length: 72 inches.

B. Y-Pattern Strainers:
   1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
   2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
   3. Strainer Screen: 40 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
C. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.3 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.


2.4 MANUAL GAS SHUTOFF VALVES

A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
   1. CWP Rating: 125 psig.
   3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
   5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
   6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

C. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.
   1. CWP Rating: 125 psig.
   2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
   4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

D. Three-Piece, Full-Port, Brass Ball Valves with Bronze Trim: MSS SP-110.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. BrassCraft Manufacturing Company; a Masco company.
c. Lyall, R. W. & Company, Inc.
e. Perfection Corporation; a subsidiary of American Meter Company.
f. Or Approved Substitute.

3. Ball: Chrome-plated bronze.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Threaded-body packnut design with adjustable-stem packing.
8. CWP Rating: 600 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Bronze Plug Valves: MSS SP-78.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Lee Brass Company.
   c. Or Approved Substitute.
5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig.
7. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

F. PE Ball Valves: Comply with ASME B16.40.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Kerotest Manufacturing Corp.
EMERGENCY GENERATOR AND DATA CENTER HVAC UPGRADES

2. Body: PE.
3. Ball: PE.
5. Seats and Seals: Nitrile.
6. Ends: Plain or fusible to match piping.
7. CWP Rating: 80 psig.
8. Operating Temperature: Minus 20 to plus 140 deg F.
9. Operator: Nut or flat head for key operation.
10. Include plastic valve extension.
11. Include tamperproof locking feature for valves where indicated on Drawings.

G. Valve Boxes:

1. Cast-iron, two-section box.
2. Top section with cover with "GAS" lettering.
3. Bottom section with base to fit over valve and barrel a minimum of 5 inches in diameter.
4. Adjustable cast-iron extensions of length required for depth of bury.
5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

2.5 EARTHQUAKE VALVES

A. Earthquake Valves: Comply with ASCE 25. Refer to sheet P-002

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Vanguard Valves, Inc.
   b. Koso.
   c. Pacific Siesmic.
   d. Or Approved Substitute.

2. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
3. Maximum Operating Pressure: 5 psig.
5. Nitrile-rubber valve washer.
7. Threaded end connections complying with ASME B1.20.1.
8. Wall mounting bracket with bubble level indicator.
2.6 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Service Pressure Regulators: Comply with ANSI Z21.80.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Actaris.
   b. American Meter Company.
   c. Fisher Control Valves and Regulators; Division of Emerson Process Management.
   d. Invensys.
   e. Or Approved Substitute.

2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 100 psig.

2.7 SERVICE METERS

A. Turbine Meters: Comply with ASME MFC-4M.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. American Meter Company.
   b. Invensys.
2.8 DIELECTRIC FITTINGS

A. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Central Plastics Company.
   e. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
   f. Wilkins; Zurn Plumbing Products Group.
   g. Or Approved Substitute.

3. Combination fitting of copper alloy and ferrous materials.
4. Insulating materials suitable for natural gas.
5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

B. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Central Plastics Company.
   c. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
   d. Wilkins; Zurn Plumbing Products Group.
   e. Or Approved Substitute.

3. Combination fitting of copper alloy and ferrous materials.
4. Insulating materials suitable for natural gas.
5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

C. Dielectric-Flange Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Advance Products & Systems, Inc.
   b. Calpico Inc.
   c. Central Plastics Company.
   d. Pipeline Seal and Insulator, Inc.
   e. Or Approved Substitute.

3. Companion-flange assembly for field assembly.
4. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or PE bolt sleeves, phenolic washers, and steel backing washers.
5. Insulating materials suitable for natural gas.
6. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

2.9 SLEEVES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

2.10 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Advance Products & Systems, Inc.
   b. Calpico Inc.
   c. Metraflex Company (The).
   d. Pipeline Seal and Insulator, Inc.
   e. Or Approved Substitute.
2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe and sleeve.
4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one nut and bolt for each sealing element.

2.11 ESCUTCHEONS

A. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to fit around pipe or tube, and OD that completely covers opening.
B. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.
C. One-Piece, Cast-Brass Escutcheons: With set screw.
   1. Finish: Polished chrome-plated.
D. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.
   1. Finish: Polished chrome-plated.

2.12 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.
B. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to NFPA 54 to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with NFPA 54 requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

A. Comply with NFPA 54 for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 18 inches below finished grade. Comply with requirements as specified.

C. Install underground, PE, natural-gas piping according to ASTM D 2774.

D. Steel Piping with Protective Coating:
   1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
   2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
   3. Replace pipe having damaged PE coating with new pipe.

E. Install fittings for changes in direction and branch connections.

F. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using 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.
   1. Install steel pipe for sleeves smaller than 6 inches in diameter.
   2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.

G. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for 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.

H. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
I. Install pressure gage downstream from each service regulator as specified.

3.4 INDOOR PIPING INSTALLATION

A. Comply with NFPA 54 for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

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

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Install escutcheons at penetrations of interior walls, ceilings, and floors.

1. New Piping:
   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   b. Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
   c. Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
   d. Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
e. Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type and set screw.
f. Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated finish.
g. Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed hinge and set screw.
h. Piping in Equipment Rooms: One-piece, cast-brass type.

2. Existing Piping:
   a. Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
b. Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
c. Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
d. Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
e. Piping in Unfinished Service Spaces: Split-casting, cast-brass type with polished chrome-plated finish.
f. Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed hinge and set screw or spring clips.
g. Piping in Equipment Rooms: Split-casting, cast-brass type.
h. Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
i. Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.

L. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements as specified.

M. Verify final equipment locations for roughing-in.

N. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

O. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as...
connected pipe. Install with space below bottom of drip to remove plug or cap.

P. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

Q. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

R. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.

1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.

2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.

3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.

4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.

   a. Exception: Tubing passing through partitions or walls does not require striker barriers.

5. Prohibited Locations:

   a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.

   b. Do not install natural-gas piping in solid walls or partitions.

S. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

T. Connect branch piping from top or side of horizontal piping.
U. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

V. Do not use natural-gas piping as grounding electrode.

W. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

X. Install pressure gage downstream from each line regulator as specified.

3.5 SERVICE-METER ASSEMBLY INSTALLATION

A. Install service-meter assemblies aboveground, on concrete bases.

B. Install metal shutoff valves upstream from service regulators. Shutoff valves are not required at second regulators if two regulators are installed in series.

C. Install strainer on inlet of service-pressure regulator and meter set.

D. Install service regulators mounted outside with vent outlet horizontal or facing down. Install screen in vent outlet if not integral with service regulator.

E. Install metal shutoff valves upstream from service meters. Install dielectric fittings downstream from service meters.

F. Install service meters downstream from pressure regulators.

G. Install metal bollards to protect meter assemblies. Comply with requirements as specified.

3.6 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install earthquake valves aboveground outside buildings according to listing.

E. Install anode for metallic valves in underground PE piping.
3.7 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:
   1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
   2. Cut threads full and clean using sharp dies.
   3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
   4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
   5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:
   2. Bevel plain ends of steel pipe.
   3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

F. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
   1. Plain-End Pipe and Fittings: Use butt fusion.
   2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.8 HANGER AND SUPPORT INSTALLATION

A. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
   1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
   2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
   3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

B. Install hangers for horizontal drawn-temper copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 3/8: Maximum span, 48 inches; minimum rod size, 3/8 inch.
2. NPS 1/2 and NPS 5/8: Maximum span, 72 inches; minimum rod size, 3/8 inch.
3. NPS 3/4 and NPS 7/8: Maximum span, 84 inches; minimum rod size, 3/8 inch.
4. NPS 1: Maximum span, 96 inches; minimum rod size, 3/8 inch.

C. Install hangers for horizontal, corrugated stainless-steel tubing with the following maximum spacing and minimum rod sizes:

1. NPS 3/8: Maximum span, 48 inches; minimum rod size, 3/8 inch.
2. NPS 1/2: Maximum span, 72 inches; minimum rod size, 3/8 inch.
3. NPS 3/4 and Larger: Maximum span, 96 inches; minimum rod size, 3/8 inch.

3.9 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.10 LABELING AND IDENTIFYING

A. Comply with requirements as specified for piping and valve identification. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.
3.11 PAINTING

A. Comply with requirements as specified for painting interior and exterior natural-gas piping.

B. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Alkyd System: MPI EXT 5.1D.
   c. Topcoat: Exterior alkyd enamel (flat).
   d. Color: Gray.

C. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Latex Over Alkyd Primer System: MPI INT 5.1Q.
   c. Topcoat: Interior latex (flat).
   d. Color: Gray.

D. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.12 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain earthquake valves.

3.13 OUTDOOR PIPING SCHEDULE

A. Underground natural-gas piping shall be the following:

1. PE pipe and fittings joined by heat fusion, or mechanical couplings; service-line risers with tracer wire terminated in an accessible location.

B. Aboveground natural-gas piping shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
3.14 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG

A. Aboveground, branch piping NPS 2” and smaller shall be the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping 2-1/2” and larger shall be the following:
   1. Steel pipe with malleable-iron welded fittings.

3.15 UNDERGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility’s gas mains and listed by an NRTL.

B. Underground:
   1. PE valves.
   2. NPS 2 and Smaller: Bronze plug valves.
   3. NPS 2-1/2 and Larger: Cast-iron, lubricated plug valves.

3.16 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 and smaller at service meter shall be the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.
   2. Bronze plug valve.

B. Valves for pipe sizes NPS 2-1/2 and larger at service meter shall be the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.
   2. Bronze plug valve.

C. Distribution piping valves for pipe sizes NPS 2 and smaller shall be the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.
   2. Bronze plug valve.

D. Distribution piping valves for pipe sizes NPS 2-1/2 and larger shall be the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.
   2. Bronze plug valve.
   3. Cast-iron, lubricated plug valve.
E. Valves in branch piping for single appliance shall be the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

END OF SECTION 231123
SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

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

1.2 SUMMARY
   A. This Section includes refrigerant piping used for air-conditioning applications.

1.3 PERFORMANCE REQUIREMENTS
   A. Line Test Pressure for Refrigerant R-22:
      3. Hot-Gas and Liquid Lines: 325 psig.
   B. Line Test Pressure for Refrigerant R-134a:
   C. Line Test Pressure for Refrigerant R-407C:
   D. Line Test Pressure for Refrigerant R-410A:

1.4 SUBMITTALS
   A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:
      1. Thermostatic expansion valves.
2. Solenoid valves.
3. Hot-gas bypass valves.
4. Filter dryers.
5. Strainers.
6. Pressure-regulating valves.

B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.

1. Shop Drawing Scale: 1/4 inch equals 1 foot.
2. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

C. Welding certificates.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."


C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.6 PRODUCT STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.7 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are as specified.
PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 88, Type K or L.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

E. Brazing Filler Metals: AWS A5.8.

F. Flexible Connectors:
   2. End Connections: Socket ends.
   3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch long assembly.
   5. Maximum Operating Temperature: 250 deg F.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; Type, Grade, and wall thickness as selected in Part 3 piping applications articles.

B. Wrought-Steel Fittings: ASTM A 234/A 234M, for welded joints.

C. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.


E. Flanged Unions:
   1. Body: Forged-steel flanges for NPS 1 to NPS 1-1/2 and ductile iron for NPS 2 to NPS 3. Apply rust-resistant finish at factory.
   2. Gasket: Fiber asbestos free.
   3. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
   4. End Connections: Brass tailpiece adapters for solder-end connections to copper tubing.
5. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch long assembly.
7. Maximum Operating Temperature: 330 deg F.

F. Flexible Connectors:
   2. End Connections:
      a. NPS 2 and Smaller: With threaded-end connections.
      b. NPS 2-1/2 and Larger: With flanged-end connections.
   3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
   5. Maximum Operating Temperature: 250 deg F.

2.3 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:
   1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
   3. Operator: Rising stem and hand wheel.
   5. End Connections: Socket, union, or flanged.
   7. Maximum Operating Temperature: 275 deg F.

B. Packed-Angle Valves:
   1. Body and Bonnet: Forged brass or cast bronze.
   2. Packing: Molded stem, back seating, and replaceable under pressure.
   3. Operator: Rising stem.
   5. Seal Cap: Forged-brass or Valox hex cap.
   6. End Connections: Socket, union, threaded, or flanged.
   8. Maximum Operating Temperature: 275 deg F.

C. Check Valves:
   1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
   2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig.
9. Maximum Operating Temperature: 275 deg F.

D. Service Valves:
1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
4. End Connections: Copper spring.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 208 V ac coil.
7. Maximum Operating Temperature: 240 deg F.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
4. End Connections: Threaded.
6. Maximum Operating Temperature: 240 deg F.

G. Thermostatic Expansion Valves: Comply with ARI 750.
1. Body, Bonnet, and Seal Cap: Forged brass or steel.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 deg F.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.

1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
5. Seat: Polytetrafluoroethylene.
6. Equalizer: Internal
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 208-V ac coil.
11. Maximum Operating Temperature: 240 deg F.

I. Straight-Type Strainers:

2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
5. Maximum Operating Temperature: 275 deg F.

J. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
6. Maximum Operating Temperature: 275 deg F.

K. Moisture/Liquid Indicators:

2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
5. End Connections: Socket or flare.
7. Maximum Operating Temperature: 240 deg F.

L. Replaceable-Core Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Designed for reverse flow (for heat-pump applications).
5. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
6. Maximum Pressure Loss: 2 psig
7. Rated Flow: As specified on plans.
9. Maximum Operating Temperature: 240 deg F.

M. Permanent Filter Dryers: Comply with ARI 730.

2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Designed for reverse flow (for heat-pump applications).
5. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
6. Maximum Pressure Loss: 2 psig
7. Rated Flow: As specified on plans.
9. Maximum Operating Temperature: 240 deg F.

N. Mufflers:

2. End Connections: Socket or flare.
4. Maximum Operating Temperature: 275 deg F.

O. Receivers: Comply with ARI 495.

1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
7. Maximum Operating Temperature: 275 deg F.

P. Liquid Accumulators: Comply with ARI 495.

2. End Connections: Socket or threaded.
4. Maximum Operating Temperature: 275 deg F.
2.4 REFRIGERANTS

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. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.
5. Or Approved Substitute.

C. ASHRAE 34, R-22: Monochlorodifluoromethane.

D. ASHRAE 34, R-134a: Tetrafluoroethane.

E. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.

F. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

B. Suction Lines NPS 4 and Smaller for Conventional Air-Conditioning Applications: Copper, Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.

C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with soldered joints.

D. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.

E. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:

1. NPS 1-1/2 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with soldered joints.
2. NPS 1-1/2 and Smaller: Copper, Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.
3. NPS 2 to NPS 3: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with soldered joints.
4. NPS 4: Copper, Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.

F. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

G. Safety-Relief-Valve Discharge Piping: Copper, Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.

H. Safety-Relief-Valve Discharge Piping:
   1. NPS 1-1/2 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with soldered joints.
   2. NPS 1-1/2 and Smaller: Copper, Type L, drawn-temper tubing and wrought-copper fittings with brazed joints.
   3. NPS 2 to NPS 3: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with soldered joints.
   4. NPS 4: Copper, Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.

E. Install a full-sized, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
   1. Install valve so diaphragm case is warmer than bulb.
   2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
   3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
H. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
   1. Solenoid valves.
   2. Thermostatic expansion valves.
   3. Hot-gas bypass valves.
   4. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

L. Install receivers sized to accommodate pump-down charge.

M. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

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

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.
J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified if valves or equipment requiring maintenance is concealed behind finished surfaces.

L. Install refrigerant piping in protective conduit where installed belowground.

M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

N. Slope refrigerant piping as follows:
   1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
   2. Install horizontal suction lines with a uniform slope downward to compressor.
   3. Install traps and double risers to entrain oil in vertical runs.
   4. Liquid lines may be installed level.

O. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

P. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
   1. Shot blast the interior of piping.
   2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
   3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
   4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
   5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
   6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

Q. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

R. Identify refrigerant piping and valves as specified.

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves as specified.

T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals as specified.
U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons as specified.

3.4 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
   1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
   2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

F. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

H. Welded Joints: Construct joints according to AWS D10.12/D10.12M.

I. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.5 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are as specified.
B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
7. NPS 2-1/2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
8. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.
9. NPS 4: Maximum span, 12 feet; minimum rod size, 1/2 inch.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
2. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
3. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
4. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2 inch.

E. Support multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
   a. Fill system with nitrogen to the required test pressure.
b. System shall maintain test pressure at the manifold gage throughout duration of test.
c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300
SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1. Rectangular ducts and fittings.
2. Single-wall, round spiral-seam ducts and formed fittings.
3. Duct liner.

1.3 SYSTEM DESCRIPTION

A. Duct system design, as indicated, has been used to select size and type of air-moving and -distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by Engineer. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.4 SUBMITTALS

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

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Duct layout indicating sizes and pressure classes.
3. Elevations of top and bottom of ducts.
4. Dimensions of main duct runs from building grid lines.
5. Fittings.
6. Reinforcement and spacing.
7. Seam and joint construction.
8. Penetrations through fire-rated and other partitions.
9. Equipment installation based on equipment being used on Project.
10. Duct accessories, including access doors and panels.
11. Hangers and supports, including methods for duct and building attachment, vibration isolation, and seismic restraints.

B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Other systems installed in same space as ducts.
3. Ceiling- and wall-mounting access doors and panels required to provide access to dampers and other operating devices.
4. Ceiling-mounting items, including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

C. Welding certificates.

D. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports.

B. NFPA Compliance:

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G60 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Carbon-Steel Sheets: ASTM A 366/A 366M, cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.

D. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

E. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 DUCT LINER

A. Fibrous-Glass Liner: Comply with NFPA 90A or NFPA 90B and with NAIMA AH124.

1. Manufacturers:
   a. CertainTeed Corp.; Insulation Group.
   c. Knauf Fiber Glass GmbH.
   d. Owens Corning.
   e. Or Approved Substitute.

2. Materials: ASTM C 1071; surfaces exposed to airstream shall be coated to prevent erosion of glass fibers.

   a. Thickness: 1 inch.
   b. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
   c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
   d. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
   e. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in duct.

      1) Tensile Strength: Indefinitely sustain a 50-lb- tensile, dead-load test perpendicular to duct wall.
      2) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.
      3) Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.
2.4 SEALANT MATERIALS

A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.

B. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.

C. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

D. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.5 HANGERS AND SUPPORTS

A. Building Attachments: Concrete inserts or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

B. Hanger Materials: Galvanized sheet steel or threaded steel rod.

   1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
   2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
   3. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.

C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.

   3. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.

2.6 RECTANGULAR DUCT FABRICATION

A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness,
reinforcing types and intervals, tie-rod applications, and joint types and intervals.

1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.

2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.

1. Manufacturers:
   a. Ductmate Industries, Inc.
   b. Nexus Inc.
   c. Ward Industries, Inc.
   d. Or Approved Substitute.

C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, cleat, and gasket details.

1. Manufacturers:
   a. Ductmate Industries, Inc.
   b. Lockformer.
   c. Or Approved Substitute.

2. Duct Size: Maximum 30 inches wide and up to 2-inch wg pressure class.

3. Longitudinal Seams: Pittsburgh lock sealed with noncuring polymer sealant.

D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of nonbraced panel area unless ducts are lined.

2.7 APPLICATION OF LINER IN RECTANGULAR DUCTS

A. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.

B. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.

C. Butt transverse joints without gaps and coat joint with adhesive.

D. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
E. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.

F. Apply adhesive coating on longitudinal seams.

G. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.

H. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

1. Fan discharges.
2. Intervals of lined duct preceding unlined duct.
3. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm (12.7 m/s) or where indicated.

I. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.8 ROUND DUCT AND FITTING FABRICATION

A. Diameter as applied to flat-oval ducts in this Article is the diameter of a round duct with a circumference equal to the perimeter of a given size of flat-oval duct.

B. Round, Spiral Lock-Seam Ducts: Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

1. Manufacturers:
   b. SEMCO Incorporated.
   c. Or Approved Substitute.

C. Duct Joints:
   1. Ducts up to 20 Inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
   2. Ducts 21 to 72 Inches in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.
   3. Ducts Larger Than 72 Inches in Diameter: Companion angle flanged joints per SMACNA "HVAC Duct Construction Standards--Metal and Flexible," Figure 3-2.
4. Round Ducts: Prefabricated connection system consisting of double-lipped, EPDM rubber gasket. Manufacture ducts according to connection system manufacturer’s tolerances.

   a. Manufacturers:

      1) Ductmate Industries, Inc.
      2) Lindab Inc.
      3) Or Approved Substitute.

D. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA’s "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.

E. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.

F. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Unless elbow construction type is indicated, fabricate elbows as follows:

   1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA’s "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.

   2. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from 2- to 10-inch wg:

      a. Ducts 3 to 26 Inches in Diameter: 0.034 inch.
      b. Ducts 27 to 50 Inches in Diameter: 0.040 inch.
      c. Ducts 52 to 60 Inches in Diameter: 0.052 inch.
      d. Ducts 62 to 84 Inches in Diameter: 0.064 inch.

   3. Round Elbows 8 Inches and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.

   4. Round Elbows 9 through 14 Inches in Diameter: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees unless space restrictions require mitered elbows. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.

   5. Round Elbows Larger Than 14 Inches in Diameter and All Flat-Oval Elbows: Fabricate gored elbows unless space restrictions require mitered elbows.

PART 3 - EXECUTION

3.1 DUCT APPLICATIONS

   A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:
1. Supply Ducts: 2-inch wg.
2. Supply Ducts (before Air Terminal Units): 2-inch wg.

3.2 DUCT INSTALLATION

A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.

B. Install round and flat-oval ducts in lengths not less than 12 feet unless interrupted by fittings.

C. Install ducts with fewest possible joints.

D. Install fabricated fittings for changes in directions, size, and shape and for connections.

E. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of 3 screws in each coupling.

F. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.

J. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

K. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.

L. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

M. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.
N. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant.

O. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic force required by applicable building codes. Refer to SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems. 2000 Supplement, Connection Level "AA"

P. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's "Duct Cleanliness for New Construction."

Q. Paint interiors of metal ducts, that do not have duct liner, for 24 inches upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized-steel primer.

3.3 SEAM AND JOINT SEALING

A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated.

1. For pressure classes lower than 2-inch wg, seal transverse joints.

B. Seal ducts before external insulation is applied.

3.4 HANGING AND SUPPORTING

A. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.

B. Support vertical ducts at maximum intervals of 16 feet and at each floor.

C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.

D. Install concrete inserts before placing concrete.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors as specified.

B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 CLEANING NEW SYSTEMS

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

C. Vent vacuuming system to the outside. Include filtration to contain debris removed from HVAC systems, and locate exhaust down wind and away from air intakes and other points of entry into building.

D. Clean the following metal duct systems by removing surface contaminants and deposits:
1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
5. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.

E. Mechanical Cleaning Methodology:
1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

F. Cleanliness Verification:
1. Visually inspect metal ducts for contaminants.
2. Where contaminants are discovered, re-clean and reinspect ducts.
EMERGENCY GENERATOR AND DATA CENTER HVAC UPGRADES

METAL DUCTS 233113
SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Backdraft dampers.
2. Volume dampers.
3. Combination fire and smoke dampers.
4. Turning vanes.
5. Duct-mounted access doors.
6. Flexible connectors.
7. Flexible ducts.
8. Duct accessory hardware.

1.3 SUBMITTALS

A. Product Data: For the following:

1. Backdraft dampers.
2. Volume dampers.
3. Combination fire and smoke dampers.
4. Turning vanes.
5. Duct-mounted access doors.
6. Flexible connectors.
7. Flexible ducts.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Special fittings.
3. Combination fire-and smoke-damper installations, including sleeves and duct-mounting access doors.
C. Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinating penetrations and ceiling-mounting items. Show ceiling-mounting access panels and access doors required for access to duct accessories.

1.4 QUALITY ASSURANCE


1.5 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed or a minimum of 5, whichever is greater.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G60 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.
2.3 BACKDRAFT DAMPERS

A. Manufacturers:
   1. Greenheck.
   2. Penn Ventilation Company, Inc.
   3. Ruskin Company.
   4. Or Approved Substitute.

B. Description: Multiple-blade, parallel action gravity balanced, with center-pivoted blades of maximum 6-inch width, with sealed edges, assembled in rattle-free manner with 90-degree stop, steel ball bearings, and axles; adjustment device to permit setting for varying differential static pressure.

C. Frame: 0.052-inch thick, galvanized sheet steel, with welded corners and mounting flange.

D. Blades: 0.025-inch thick, roll-formed aluminum.

E. Blade Seals: Felt.

F. Blade Axles: Nonferrous.

G. Tie Bars and Brackets: Galvanized steel.

H. Return Spring: Adjustable tension.

2.4 VOLUME DAMPERS

A. Manufacturers:
   1. Titus
   3. Nailor Industries Inc.
   4. Or Approved Substitute.

B. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.

   1. Pressure Classes of 3-Inch wg or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.

C. Low-Leakage Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, low-leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.
1. Steel Frames: U-shaped, galvanized sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
2. Roll-Formed Steel Blades: 0.064-inch-thick, galvanized sheet steel.
3. Aluminum Frames: U-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
4. Roll-Formed Aluminum Blades: 0.10-inch-thick aluminum sheet.
5. Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.
7. Bearings: Oil-impregnated bronze thrust or ball.

D. Jackshaft: 1-inch-diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.

1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.

E. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

2.5 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers:

1. Ruskin FSD-60 or equal Class 1 by manufacturer listed below.
2. Potorff.
3. Ruskin Company.
5. Or Approved Substitute.

B. General Description: Labeled according to UL 555S. Combination fire and smoke dampers shall be labeled according to UL 555 for 1-1/2-hour rating. Class 1 leakage rating.

C. Fusible Links: Replaceable, 165 deg F rated.

D. Frame and Blades: 0.064-inch-thick, galvanized sheet steel.

E. Mounting Sleeve: Factory-installed, 0.052-inch-thick, galvanized sheet steel; length to suit wall or floor application.

F. Provide a disconnect switch for individual damper isolation.
G. Damper Motors: Modulating and two-position action.

1. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.

2. Outdoor Motors and Motors in Outside-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.

3. Electrical Connection: 115 V, single phase, 60 Hz.

4. Actuators for smoke fire dampers are to be supplied by BELIMO.

2.6 TURNING VANES

A. Fabricate to comply with SMACNA’s "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.

B. Manufactured Turning Vanes: Fabricate 1-1/2-inch- wide, single-vane, curved blades of galvanized sheet steel set 3/4 inch o.c.; support with bars perpendicular to blades set 2 inches o.c.; and set into vane runners suitable for duct mounting.

1. Manufacturers:
   a. Ductmate Industries, Inc.
   b. Duro Dyne Corp.
   c. METALAIRE, Inc.
   d. Or Approved Substitute.

C. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

2.7 DUCT-MOUNTING ACCESS DOORS

A. General Description: Fabricate doors airtight and suitable for duct pressure class.

B. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated. Include 1-by-1-inch butt or piano hinge and cam latches.

1. Manufacturers:
   a. Ductmate Industries, Inc.
   c. Ventfabrics, Inc.
   d. Or Approved Substitute.
2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Provide number of hinges and locks as follows:
   a. Less Than 12 Inches Square: Secure with two sash locks.
   b. Up to 18 Inches Square: Two hinges and two sash locks.
   c. Up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
   d. Sizes 24 by 48 Inches and Larger: One additional hinge.

C. Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with insulation fill and 1-inch thickness. Include cam latches.
   1. Manufacturers:
      a. Ductmate Industries, Inc.
      b. Flexmaster U.S.A., Inc.
      c. Or Approved Substitute.

2. Frame: Galvanized sheet steel, with spin-in notched frame.

D. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

E. Insulation: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.8 FLEXIBLE CONNECTORS

A. Manufacturers:
   1. Ductmate Industries, Inc.
   2. Duro Dyne Corp.
   3. Ventfabrics, Inc.
   5. Or Approved Substitute.

B. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Select metal compatible with ducts.

   1. Minimum Weight: 26 oz./sq. yd.
   2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
   3. Service Temperature: Minus 40 to plus 200 deg F.
2.9 FLEXIBLE DUCTS

A. Manufacturers:
   1. Flexmaster U.S.A., Inc.
   2. Hart & Cooley, Inc.
   4. Or Approved Substitute.

B. Insulated-Duct Connectors: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor barrier film.
   1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
   3. Temperature Range: Minus 10 to plus 160 deg F.

C. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 3 through 18 inches to suit duct size.

PART 3 - EXECUTION

3.1 APPLICATION AND INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.

D. Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.

E. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff.

F. Provide test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers, with fusible links, according to manufacturer's UL-approved written instructions.

H. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:
   1. On both sides of duct coils.
   2. Downstream from volume dampers, turning vanes, and equipment.
   3. Adjacent to fire or smoke dampers, providing access to reset or reinstall fusible links.
   4. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot spacing.
   5. On sides of ducts where adequate clearance is available.

I. Install the following sizes for duct-mounting, rectangular access doors:
   1. One-Hand or Inspection Access: 8 by 5 inches.
   2. Two-Hand Access: 12 by 6 inches.

J. Install the following sizes for duct-mounting, round access doors:
   1. One-Hand or Inspection Access: 8 inches in diameter.
   3. Head and Hand Access: 12 inches in diameter.

K. Install the following sizes for duct-mounting, pressure relief access doors:
   1. One-Hand or Inspection Access: 7 inches in diameter.

L. Label access doors as specified.

M. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.

N. For fans developing static pressures of 5-inch wg and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

O. Connect diffusers or light troffer boots to low pressure ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.

P. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.

Q. Install duct test holes where indicated and required for testing and balancing purposes.

3.2 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Adjust fire and smoke dampers for proper action.

C. Final positioning of manual-volume dampers as specified.

END OF SECTION 233300
SECTION 233416 - CENTRIFUGAL HVAC FANS

PART 1 - GENERAL

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

1.2 SUMMARY
   A. This Section includes the following:
      1. Plug fans.

1.3 PERFORMANCE REQUIREMENTS
   A. Project Altitude: Base fan performance ratings on sea level.
   B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS
   A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
      1. Certified fan performance curves with system operating conditions indicated.
      2. Certified fan sound-power ratings.
      3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
      4. Material thickness and finishes, including color charts.
      5. Dampers, including housings, linkages, and operators.
   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.
      2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
      3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
C. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA 1.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Comply with concrete, reinforcement, and formwork requirements as specified.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
PART 2 - PRODUCTS

2.1 PLUG FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Greenheck
2. Loren Cook Company.
4. Or Approved Substitute.

B. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure.

C. Airfoil Wheels: Single-width-single-inlet construction with smooth-curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

D. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

1. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

E. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.

1. Ball-Bearing Rating Life: ABMA 9, L10 at 120,000 hours.
2. Roller-Bearing Rating Life: ABMA 11, L10 at 120,000 hours.


1. Ball-Bearing Rating Life: ABMA 9, L10 at 120,000 hours.
2. Roller-Bearing Rating Life: ABMA 11, L10 at 120,000 hours.

G. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: 1.5.
2. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.

3. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.

4. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.

5. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.


H. Accessories:

1. MFR filter box with 2 inch MERV-9 pleated filters

I. Motors:

1. Enclosure Type: Totally enclosed, fan cooled.

2.2 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install centrifugal fans level and plumb.

B. Install floor-mounting units on concrete inertia bases with vibration isolation. Comply with concrete, reinforcement, and formwork requirements.

C. Install units with clearances for service and maintenance.

D. Label fans according to requirements as specified.
3.2 CONNECTIONS

A. Duct installation and connection requirements as specified. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors.

B. Install ducts adjacent to fans to allow service and maintenance.

C. Install line-sized piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain.

D. Ground equipment as specified.

E. Connect wiring as specified.

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 233416
SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Shutoff single-duct air terminal units.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.

1. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.
2. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

D. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 include the following:

1. Instructions for resetting minimum and maximum air volumes.
2. Instructions for adjusting software set points.
1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units and are based on the specific system indicated.

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

C. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

1.5 COORDINATION

A. Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 SHUTOFF SINGLE-DUCT AIR TERMINAL UNITS

A. Manufacturers:

1. Titus.
2. Anemostat; a Mestek Company.
4. Or Approved Substitute.

B. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal shroud.

C. Casing: 0.034-inch steel.

2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket.

D. Regulator Assembly: Extruded-aluminum or galvanized-steel components; key damper blades onto shaft with nylon-fitted pivot points located inside unit casing.
1. Automatic Flow-Control Assembly: Combined spring rates shall be matched for each volume-regulator size with machined dashpot for stable operation.
2. Factory-calibrated and field-adjustable assembly with shaft extension for connection to externally mounted control actuator.

E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.

F. Attenuator Section: 0.034-inch steel sheet metal.

1. Lining: 1-inch-thick, coated, fibrous-glass duct liner complying with ASTM C 1071; secured with adhesive. Cover liner with nonporous foil.

G. Multioutlet Attenuator Section: With two, three, or four collars; each with locking butterfly balancing damper. Refer to plans for quantity and size of connections.

H. Hot-Water Heating Coil: Copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig; and factory installed.

I. Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer and room sensor shall be compatible with temperature controls and shall have the following features:

1. Damper Actuator: 24 V-ac or 24 V-dc, powered closed, spring return open.
2. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg; and shall have a multipoint velocity sensor at air inlet.
3. Thermostat: Wall-mounting electronic type with the following features:
   a. Proportional, plus integral control of room temperature.
   b. Time-proportional reheat-coil control.
   c. Temperature set-point display in Fahrenheit and Celsius.

J. DDC Controls: Single-package unitary controller and actuator as specified.

K. Control Sequence:

1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg inlet static pressure.
2. Factory-mounted and -piped, 5-micron filter; velocity-resetting, adjustable, high-limit control; and amplifying relay.

### 2.2 SOURCE QUALITY CONTROL

A. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

B. Verification of Performance: Rate air terminal units according to ARI 880.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

A. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

#### 3.2 CONNECTIONS

A. Piping installation requirements as specified. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air terminal units to allow service and maintenance.

C. Connect ducts to air terminal units as specified.

D. Connect wiring as specified.

E. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer’s torque values are not indicated, use those specified in UL 486A and UL 486B.

#### 3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.
3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600
SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

1.3 SUBMITTALS

A. Product Data: For each product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.

2. Diffuser, Register, and Grille Schedule: Indicate Drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 GRILLES AND REGISTERS

A. Adjustable Bar Grille:

1. Manufacturers:

   a. Titus 350 or 300 series (or Equal)
   b. Nailor Industries of Texas Inc.
   c. Tuttle & Bailey.
   d. Or Approved Substitute.

3. Finish: Baked enamel, white.
7. Mounting: Countersunk screw.
8. Damper Type: Adjustable opposed-blade assembly.

2.3 CEILING DIFFUSER OUTLETS

A. Round Ceiling Diffuser:

1. Manufacturers:

   a. Titus TMR (or Equal).
   b. Nailor Industries of Texas Inc.
   c. Tuttle & Bailey.
   d. Or Approved Substitute.

3. Finish: Baked enamel, white.
4. Face Style: Four cone.
7. Accessories:

   a. Equaling grid.
   b. Plaster ring.
   c. Safety chain.
   d. Wire guard.
   e. Sectorizing baffles.
   f. Operating rod extension.
   g. Square To Round Duct Transition on Diffuser Neck.

B. Perforated Diffuser
1. Manufacturers:
   a. Titus - PMC, PMR, PAR (or Equal)
   b. Nailor Industries of Texas Inc.
   c. Tuttle & Bailey.
   d. Or Approved Substitute.

2. Material: Steel backpan and pattern controllers, with steel face.
3. Finish: Baked enamel, white.
4. Face Size: 24 by 24 inches.
5. Duct Inlet: Square.
7. Pattern Controller: Adjustable with louvered pattern modules at inlet.
10. Accessories:
   C. Louver Face Diffuser

1. Manufacturers:
   a. Titus MCD (Or Equal).
   b. Nailor Industries of Texas Inc.
   c. Tuttle & Bailey.
   d. Or Approved Substitute.

3. Finish: Baked enamel, white.
4. Face Size: Neck Size Plus 5".
5. Mounting: Surface.
8. Accessories:
   a. Square to round neck adaptor.
   b. Adjustable pattern vanes.
   c. Equaling grid.
   d. Plaster ring.
   e. Jiffy Frame

2.4 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where Engineering features or other items conflict with installation, notify Engineer for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713
SECTION 236200 - PACKAGED COMPRESSOR AND CONDENSER UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes packaged, refrigerant compressor and condenser units.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Compressor and condenser units 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."

1.4 SUBMITTALS

A. Product Data: For each compressor and condenser unit. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include equipment dimensions, weights and structural loads, required clearances, method of field assembly, components, and location and size of each field connection.

B. Shop Drawings: For compressor and condenser units. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For compressor and condenser units indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

D. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members to which compressor and condenser units will be attached.
2. Liquid and vapor pipe sizes.
3. Refrigerant specialties.
4. Piping including connections, oil traps, and double risers.
5. Compressors.

E. Seismic Qualification Certification: For compressor and condenser units, 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.

F. Field quality-control reports.

G. Warranty: Sample of special warranty.

H. Operation and Maintenance Data: For compressor and condenser units to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

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. Fabricate and label refrigeration system according to ASHRAE 15, "Safety Standard for Refrigeration Systems."

C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6, "Heating, Ventilating, and Air-Conditioning."

D. ASME Compliance: Fabricate and label water-cooled compressor and condenser units to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
1.6 COORDINATION

A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are as specified.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are as specified.

C. Coordinate location of piping and electrical rough-ins.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of compressor and condenser units that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

   a. Compressor failure.
   b. Condenser coil leak.

2. Warranty Period: Five years from date of Substantial Completion.
3. Warranty Period (Compressor Only): Five years from date of Substantial Completion.
4. Warranty Period (Components Other Than Compressor): Five years from date of Substantial Completion.
5. Warranty Period (Condenser Coil Only): Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 COMPRESSOR AND CONDENSER UNITS, AIR COOLED, 1 TO 5 TONS

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 Liebert Model MCM040 or comparable product by one of the following:

1. Carrier Corporation; Commercial HVAC Systems.
2. Lennox International Inc.
3. Rheem Air Conditioning Division.
4. Or Approved Substitute.

C. Description: Factory assembled and tested; consisting of compressor, condenser coil, fan, motors, refrigerant reservoir, and operating controls.

D. Compressor: Scroll, hermetically sealed, with rubber vibration isolators.
1. Motor: Two speed, and includes thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

2. Two-Speed Compressor: Include manual-reset, high-pressure switch and automatic-reset, low-pressure switch.


E. Refrigerant: R-410A.

F. Condenser Coil: Seamless copper-tube, aluminum-fin coil; circuited for integral liquid subcooler, with removable drain pan and brass service valves with service ports.

G. Condenser Fan: Direct-drive, aluminum propeller fan; with permanently lubricated, totally enclosed fan motor with thermal-overload protection and ball bearings.

H. Accessories:
   1. Coastal Filter: Mesh screen to protect condenser coil from salt damage.
   2. Crankcase heater.
   3. Cycle Protector: Automatic-reset timer to prevent rapid compressor cycling.
   4. Electronic programmable thermostat to control compressor and condenser unit and evaporator fan.
   5. Evaporator Freeze Thermostat: Temperature-actuated switch that stops unit when evaporator reaches freezing temperature.
   7. High-Pressure Switch: Automatic-reset switch cycles compressor off on high refrigerant pressure.
   8. Liquid-line solenoid.
   9. Low-Ambient Controller: Cycles condenser fan to permit operation down to 0 deg F.
   10. Low-Ambient Controller: Controls condenser fan speed to permit operation down to minus 20 deg F.
   11. Low-Pressure Switch: Automatic-reset switch cycles compressor off on low refrigerant pressure.
   12. PE mounting base.
   13. Precharged and insulated suction and liquid tubing.
   15. Thermostatic expansion valve.
   16. Time-Delay Relay: Continues operation of evaporator fan after compressor shuts off.
   17. Reversing valve.
   18. Additional accessories as specified on plans.

I. Unit Casing: Galvanized steel, finished with baked enamel; with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Mount service valves, fittings, and gage ports on exterior of casing.

J. Capacities and Characteristics:
1. Compressor and Condenser Unit:
   a. Full-Load Cooling Capacity: As specified on plans.
   b. Energy-Efficiency Ratio (EER): As specified on plans.
   c. Seasonal Energy-Efficiency Ratio (SEER): As specified on plans.
   d. Coefficient of Performance (COP): As specified on plans.
   e. Compressor Suction Temperature: As specified on plans.
   f. Capacity Steps: As specified on plans.

2. Refrigerant Connections:
   a. Liquid Pipe Size: As specified on plans.
   b. Suction Pipe Size: As specified on plans.

3. Compressor:
   a. Rated-Load Amperes: As specified on plans.
   b. Locked-Rotor Amperes: As specified on plans.
   c. Power Input: As specified on plans.

4. Air-Cooled Condenser:
   a. Ambient-Air Temperature: As specified on plans.
   b. Airflow: As specified on plans.
   c. Number of Condenser Fans: As specified on plans.
   d. Condenser Fan Motor Size: As specified on plans.

5. Electrical Characteristics:
   a. Volts: As specified on plans.
   b. Phase: As specified on plans.
   c. Hertz: As specified on plans.
   d. Minimum Circuit Amperes: As specified on plans.
   e. Maximum Instantaneous Current Flow during Startup: As specified on plans.
   f. Maximum Overcurrent Protection: As specified on plans.

2.2 COMPRESSOR AND CONDENSER UNITS, AIR COOLED, 6 TO 120 TONS

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 Trane 4TVR0072B400NB or comparable product by one of the following:

1. Johnson Controls/York.
2. Mitsubishi.
3. Or Approved Substitute.
C. Description: Factory assembled and tested, air cooled; consisting of casing, compressors, condenser coils, condenser fans and motors, and unit controls.

D. Compressor: Hermetic scroll compressor designed for service with crankcase sight glass, crankcase heater, and backseating service access valves on suction and discharge ports.

E. Compressor: Hermetic or semihermetic rotary screw compressor designed for service with crankcase sight glass, crankcase heater, and backseating service access valves on suction and discharge ports.

F. Refrigerant: R-410A.

G. Condenser Coil: Seamless copper-tube, aluminum-fin coil, including subcooling circuit and backseating liquid-line service access valve. Factory pressure test coils, then dehydrate by drawing a vacuum and fill with a holding charge of nitrogen or refrigerant.

H. Condenser Fans: Propeller-type vertical discharge; either directly or belt driven. Include the following:
   1. Permanently lubricated, ball-bearing totally enclosed motors.
   2. Separate motor for each fan.
   3. Dynamically and statically balanced fan assemblies.

I. Operating and safety controls include the following:
   1. Manual-reset, high-pressure cutout switches.
   2. Automatic-reset, low-pressure cutout switches.
   3. Low-oil-pressure cutout switch.
   4. Compressor-winding thermostat cutout switch.
   5. Three-leg, compressor-overload protection.
   6. Control transformer.
   7. Magnetic contactors for compressor and condenser fan motors.
   8. Timer to prevent excessive compressor cycling.

J. Accessories:
   1. Electronic programmable thermostat to control compressor and condenser unit and evaporator fan.
   2. Low-Ambient Controller: Cycles condenser fan to permit operation down to 0 deg F.
   3. Low-Ambient Controller: Controls condenser fan speed to permit operation down to minus 20 deg F.
   5. Hot-gas bypass kit.
   6. Part-winding-start timing relay, circuit breakers, and contactors.
   7. Reversing valve.
   8. Additional accessories as specified on plans.
K. Unit Casings: Designed for outdoor installation with weather protection for components and controls and with removable panels for required access to compressors, controls, condenser fans, motors, and drives. Additional features include the following:

1. Steel, galvanized or zinc coated, for exposed casing surfaces; treated and finished with manufacturer's standard paint coating.
2. Perimeter base rail with forklift slots and lifting holes to facilitate rigging.
3. Gasketed control panel door.
4. Nonfused disconnect switch, factory mounted and wired, for single external electrical power connection.
5. Condenser coil grille.

L. Capacities and Characteristics:

1. Compressor and Condenser Unit:
   a. Full-Load Cooling Capacity: As specified on plans.
   b. Energy-Efficiency Ratio (EER): As specified on plans.
   c. Seasonal Energy-Efficiency Ratio (SEER): As specified on plans.
   d. Coefficient of Performance (COP): As specified on plans.
   e. Compressor Suction Temperature: As specified on plans.
   f. Capacity Steps: As specified on plans.

2. Refrigerant Connections:
   a. Liquid Pipe Size: As specified on plans.
   b. Suction Pipe Size: As specified on plans.

3. Compressors:
   a. Number of Compressors: As specified on plans.
   b. Rated-Load Amperes: As specified on plans.
   c. Locked-Rotor Amperes: As specified on plans.
   d. Power Input: As specified on plans.

4. Air-Cooled Condenser:
   a. Ambient-Air Temperature: As specified on plans.
   b. Airflow: As specified on plans.
   c. Number of Condenser Fans: As specified on plans.
   d. Condenser Fan Motor Size: As specified on plans.

5. Electrical Characteristics:
   a. Volts: As specified on plans.
   b. Phase: As specified on plans.
   c. Hertz: As specified on plans.
   d. Minimum Circuit Ampacity: As specified on plans.
   e. Maximum Instantaneous Current Flow during Startup: As specified on plans.
f. Maximum Overcurrent Protection: As specified on plans.

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors as specified.

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.

2.4 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate compressor and condenser units according to ARI 206/110

B. Test and inspect shell and tube condensers according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

C. Testing Requirements: Factory test sound-power-level ratings according to ARI 270

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of compressor and condenser units.

B. Examine roughing-in for refrigerant piping systems to verify actual locations of piping connections before equipment installation.

C. Examine walls, floors, and roofs for suitable conditions where compressor and condenser units will be installed.

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

3.2 INSTALLATION

A. Install units level and plumb, firmly anchored in locations indicated.

B. Install roof-mounting units on equipment supports as specified.

C. Equipment Mounting:
1. Install compressor and condenser units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations as specified.

2. Comply with requirements for vibration isolation and seismic control devices as specified.

3. Comply with requirements for vibration isolation devices as specified.

D. Maintain manufacturer's recommended clearances for service and maintenance.

E. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

3.3 CONNECTIONS

A. Comply with requirements for piping in other Sections as specified. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

C. Connect precharged refrigerant tubing to unit's quick-connect fittings. Install tubing so it does not interfere with access to unit. Install furnished accessories.

D. Connect refrigerant piping to air-cooled compressor and condenser units; maintain required access to unit. Install furnished field-mounted accessories. Refrigerant piping and specialties are as specified.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.

2. Leak Test: After installation, charge system with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor operation and unit operation, product capability, and compliance with requirements.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

5. Verify proper airflow over coils.
C. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

D. Compressor and condenser units will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
   a. Inspect for physical damage to unit casing.
   b. Verify that access doors move freely and are weathertight.
   c. Clean units and inspect for construction debris.
   d. Verify that all bolts and screws are tight.
   e. Adjust vibration isolation and flexible connections.
   f. Verify that controls are connected and operational.

B. Lubricate bearings on fan motors.

C. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.

D. Adjust fan belts to proper alignment and tension.

E. Start unit according to manufacturer's written instructions and complete manufacturer's startup checklist.

F. Measure and record airflow and air temperature rise over coils.

G. Verify proper operation of condenser capacity control device.

H. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

I. After startup and performance test, lubricate bearings.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain compressor and condenser units.
SECTION 238123 - COMPUTER-ROOM AIR-CONDITIONERS

PART 1 - GENERAL

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

1.2 SUMMARY
   A. Section Includes:
      1. Floor-mounted computer-room air conditioners, 5 tons and smaller.
      2. Ceiling-mounted computer-room air conditioners.
      3. Console computer-room air conditioners.

1.3 DEFINITION
   A. BAS: Building automation system.

1.4 PERFORMANCE REQUIREMENTS
   A. Seismic Performance: Computer-room air conditioners 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."

1.5 SUBMITTALS
   A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   B. Shop Drawings: For computer-room air conditioners. 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. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.

D. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from Installers of the items involved.

E. Seismic Qualification Certificates: For computer-room air conditioners, 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.

F. Field quality-control reports.

G. Warranty: Sample of special warranty.

H. Operation and Maintenance Data: For computer-room air conditioners to include in emergency, operation, and maintenance manuals.

1.6 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. Fan Belts: Two set(s) for each belt-driven fan.
2. Filters: Two set(s) of filters for each unit.

1.7 QUALITY ASSURANCE

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. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.
D. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

1.8 COORDINATION

A. Coordinate layout and installation of computer-room air conditioners and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Coordinate installation of computer-room air conditioners with computer-room access flooring Installer.

C. Coordinate sizes and locations of concrete bases with actual equipment provided.

D. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.

2. Warranty Period for Humidifiers: Manufacturer's standard, but not less than five years from date of Substantial Completion.

3. Warranty Period for Control Boards: Manufacturer's standard, but not less than five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 FLOOR-MOUNTED UNITS 5 TONS AND SMALLER

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 Liebert PX018DA or comparable product by one of the following:

1. Airflow Company; a division of The McClain Company, Inc.
2. Carrier Corporation; a United Technologies company.
3. Compu-Aire, Inc.
4. Or Approved Substitute.
C. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for vertical floor mounting in upflow or downflow configuration.

D. Cabinet and Frame: Welded tubular-steel frame with removable steel panels with baked-enamel finish, insulated with 1-inch thick duct liner.
   1. Floor Stand: Welded tubular steel, 12" high, with adjustable legs and vibration isolation pads.
   2. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

E. Supply-Air Fan: Forward curved, centrifugal, and with adjustable V-belt drive.

F. Refrigeration System:
   1. Compressor: Hermetic, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
   2. Refrigeration Circuit: Low-pressure switch, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
   3. Refrigerant: R-410A
   4. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins, with two circuits, each with solenoid valve.
      a. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1.
   7. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

G. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with modulating three-way control valve.
   2. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1

H. Remote Air-Cooled, Glycol-Solution Cooler: Corrosion-resistant cabinet, copper-tube aluminum-fin coil, direct-drive propeller fan with fan guards, and single-phase motors with internal overload protection.
1. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

I. Glycol-Solution Pump Package: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing centrifugal pump with mechanical seal.

1. Piping: Interconnecting piping, from suction to discharge, with shutoff valves, flow switches, unions, and pressurized expansion tank with air purge vent and system-charging connection.
2. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of minus 40 deg F.
3. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

J. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor and high-temperature-limit switches.

K. Filter: 2-inch thick, disposable, glass-fiber media.

1. Merv (ASHRAE 52.2): 8.

L. Infrared Humidifier: High-intensity quartz lamps mounted above stainless-steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; prepiped and located in bypass airstream; with flush-cycle timer and solenoid drain valve.

M. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.

1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain withintegral air gap.
2. Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
3. Drain Cycle: Field-adjustable drain duration and drain interval.

N. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

O. Control System: Unit-mounted panel with main fan contactor, compressor contactor, compressor start capacitor, control transformer with circuit breaker, solid-state temperature and humidity control modules, humidity contactor, time-delay relay, heating contactor, and high-temperature thermostat. Provide solid-state, wall-mounted control panel with start-stop switch, adjustable humidity set point, and adjustable temperature set point.
2.2 CEILING-MOUNTED 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 Trane 4TVB0009B100NB and 4TVW0007B100NC or comparable product by one of the following:
   1. Johnson Controls/York.
   2. Mitsubishi.
   3. Or Approved Substitute.

C. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for horizontal ceiling mounting to fit T-bar ceiling opening of 24 by 48 inches

D. Cabinet: Galvanized steel with baked-enamel finish, insulated with 1/2-inch thick duct liner.
   1. Integral factory-supplied supply and return grille to fit ceiling grid kit of 24 by 48 inches with filter.
   2. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

E. Supply-Air Fan: Forward curved, centrifugal, and directly driven by two-speed motor.

F. Refrigeration System:
   1. Compressor: Hermetic, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
   2. Refrigeration Circuit: Low-pressure switch, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
   3. Refrigerant: R-410A.
   4. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins.
      a. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1
7. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

G. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with two-way control valve.

H. Remote, Air-Cooled, Glycol-Solution Cooler: Corrosion-resistant cabinet, copper-tube aluminum-fin coil, direct-drive propeller fan with fan guards, and single-phase motors with internal overload protection.

I. Glycol-Solution Pump Package: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing centrifugal pump with mechanical seal.
   1. Piping: Interconnecting piping, to and from remote, air-cooled glycol-solution cooler, with shutoff valves, flow switches, unions, and pressurized expansion tank with air purge vent and system-charging connection.
   2. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of minus 40 deg F.

J. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor, dehumidification relay, and high-temperature-limit switches.

K. Filter: 1-inch thick, disposable, glass-fiber media.
   1. Merv (ASHRAE 52.2): 8.

L. Atomizing Humidifier: Centrifugal atomizer with stainless-steel pan, demister pad, and solenoid valve.

M. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders, and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.
   1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
   2. Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
   3. Drain Cycle: Field-adjustable drain duration and drain interval.

N. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
O. Control System: Unit-mounted panel with main fan contactor, compressor contactor, compressor start capacitor, control transformer with circuit breaker, solid-state temperature and humidity control modules, humidity contactor, time-delay relay, heating contactor, and high-temperature thermostat. Provide solid-state, wall-mounted control panel with start-stop switch, adjustable humidity set point, and adjustable temperature set point.

2.3 CAPACITIES AND CHARACTERISTICS

A. Unit Configuration:
   1. Downflow.

B. Supply-Air Fan:
   1. Number of Fans: As specified on plans.
   2. Airflow: As specified on plans.
   3. Minimum Static Pressure: As specified on plans.
   4. Motor Size: As specified on plans.

C. Refrigeration System:
   1. Unit Energy Efficiency: As specified on plans.
   2. Refrigerant Compressor:
      a. Total Unit Cooling Capacity: As specified on plans.
      b. Sensible Unit Cooling Capacity: As specified on plans.
      c. Number of Compressors: As specified on plans.
      d. Motor Size: As specified on plans.
   3. Refrigerant Evaporator Coil:
      a. Cooling Capacity: As specified on plans.
      b. Entering-Air Dry-Bulb Temperature: As specified on plans.
      c. Entering-Air Wet-Bulb Temperature: As specified on plans.
      d. Leaving-Air Dry-Bulb Temperature: As specified on plans.
      e. Leaving-Air Wet-Bulb Temperature: As specified on plans.
   4. Water-Cooled Refrigerant Condenser:
      a. Cooling Capacity: As specified on plans.
      b. Condenser Water Flow: As specified on plans.
      c. Cooling Medium: As specified on plans.
      d. Entering-Water Temperature: As specified on plans.
      e. Fluid Pressure Drop: As specified on plans.
   5. Air-Cooled Refrigerant Condenser:
      a. Cooling Capacity: As specified on plans.
      b. Entering-Air Temperature: As specified on plans.
c. Number of Condenser Fan Motors: As specified on plans.
d. Condenser Fan Motors: As specified on plans.

D. Electrical Characteristics:

1. Volts: As specified on plans.
2. Phase: As specified on plans.
3. Hertz: As specified on plans.
4. Full-Load Amperes: As specified on plans.
5. Minimum Circuit Ampacity: As specified on plans.
6. Maximum Overcurrent Protection: As specified on plans.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for hydronic piping systems to verify actual locations of piping connections before equipment installation.

C. Examine walls, floors, and roofs for suitable conditions where computer-room air conditioners will be installed.

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

3.2 INSTALLATION

A. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances. Install according to ARI Guideline B.


1. Minimum Deflection: 1 inch.

C. Suspended Computer-Room Air Conditioners: Install using continuous-thread hanger rods and spring hangers with vertical-limit stop of size required to support weight of computer-room air conditioner.

1. Comply with requirements for vibration isolation devices specified.
   Fabricate brackets or supports as required.
2. Comply with requirements for hangers and supports as specified.
   1. Minimum Deflection: 1 inch.

   1. Minimum Deflection: 1 inch.


3.3 CONNECTIONS

A. Piping installation requirements are specified in other heating, ventilating, and air-conditioning Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Water and Drainage Connections: Comply with applicable requirements as specified. Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.

D. Hot-Water Heating Piping: Comply with applicable requirements as specified. Provide shutoff valves in inlet and outlet piping to heating coils.

E. Steam and Condensate Piping: Comply with applicable requirements as specified. Provide shutoff valves in steam inlet and steam trap in condensate outlet piping to heating coils.

F. Condenser-Water Piping: Comply with applicable requirements as specified. Provide shutoff valves in water inlet and outlet piping on water-cooled units.

G. Refrigerant Piping: Comply with applicable requirements as specified. Provide shutoff valves and piping.

3.4 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. 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.
C. Tests and Inspections:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

F. After startup service and performance test, change filters and flush humidifier.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

END OF SECTION 238123
SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 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. All items of this section shall be applicable whether they are clearly shown on drawings or not. All conflicts or deviations from stated installation procedures shall be corrected by the contractor at no cost to owner or design team.

C. Contractor shall carefully review all other trades’ plans, specifications, and design documents prior to bid preparation and prior to construction.

1.2 SUMMARY

A. Section Includes:

1. Electrical equipment coordination and installation.
2. Sleeves for raceways and cables.
3. Sleeve seals.
5. Common electrical installation requirements.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For sleeve seals.

1.5 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment; along with all other trades:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. To provide for ease of disconnecting the equipment with minimum interference to other installations.

3. To allow right of way for piping and conduit installed at required slope.

4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

5. Service access shall comply with applicable provisions of the California Code of Regulations, Title 8.

6. Electrical working spaces shall comply with CEC Table 110.26(A)(1)

7. Dedicated equipment space shall comply with CEC 110.26(E) and shall switchboards, panelboards, motor control centers, variable frequency drives, and auto transfer switches, whether shown on plans or not.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed.

D. Coordinate sleeve selection and application with selection and application of firestopping as indicated.

E. Emergency cuts shall be in separate conduit from normal power in all cases. OSHPD projects may require the typical four (4) branches of power, which shall all be routed separately from each other.

F. Class 2 & 3 circuits shall be routed separately from each other.

G. Minimum conduit size shall be 3/4-inch in all cases.

H. Exposed conduit below 8'-0" shall be RMC.

I. All conduit fittings shall be compression type. Set-screen fittings shall not be permitted.

J. Sub-metering for plug-loads, lighting, and HVAC shall be accumulated separately to compose a total of all lighting, HVAC, and plug loads KWh (kW, kVAR)

K. Conduit spacing shall be a minimum of 1 inch away from any other system, such as piping and other conduit.

L. Do not fabricate, purchase, produce, or install any materials without full coordination with other trades. Ascertain that electrical systems are not in violation of other building systems’ installed requirements. Conduits shall not be placed in front of conduit, supply, or return duct bells and shall not in any way impede access of any permanent installed building requirement.
2.1 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:
   a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
   b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE SEALS

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, provide products by one of the following or available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Metraflex Co.
   d. Pipeline Seal and Insulator, Inc.
   e. Or Approved Substitute.

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 Co.
   d. Pipeline Seal and Insulator, Inc.
   e. Or Approved Substitute.

3. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.

4. Pressure Plates: Carbon steel or stainless steel. Include two for each sealing element.

5. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating or Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.
2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, non-staining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items. Heights shall comply with Americans With Disabilities Act (ADA) standards.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope, conduits must have a minimum separation from other installed systems of at least 1 inch or shall not be in contact with exterior duct installation.

F. Concrete Base: Provide minimum 4 inch high concrete housing pad underneath of all free standing electrical equipment shown on plan.

G. All electrical work shall be performed by state certified licensed electricians and apprentices working under the supervision of certified licensed electricians.

H. All work shall be performed by NFPA 70E trained personnel.

I. No work shall be performed on energized systems without prior written approval from the college. Such approval shall be obtained from the college a minimum of seven (7) days prior to the start of any such work.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2 inches above finished floor level.

G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry
   1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with penetration.

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with penetration fire protection rating and use appropriate intumescent seal.

K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using cast-iron 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.

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.
B. Use 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.

3.4 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly.

3.5 FIELD QUALITY CONTROL

A. Inspect installed sleeve and sleeve-seal installations and associated firestopping for damage and faulty work.

END OF SECTION 260500
SECTION 260519 - 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 1 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.
3. Sleeves and sleeve seals for cables.

B. Related Requirements:

1. All contract documents.

1.3 DEFINITIONS

A. VFC: Variable Frequency Controller.

B. EPDM: Ethylene-propylene-diene terpolymer rubber.

C. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For each type of product.

B. Qualification Data: For testing agency.

C. Field quality-control test reports.

D. Qualification Data: For testing agency.

E. Field quality-control reports.
1.5 QUALITY ASSURANCE

A. 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 20 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.

B. Electrical Components, Devices and Accessories: Listed and Labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70 and 70B. Post arcflash signage in all electrical panels within the scope of this project, including existing panels where new connections are made or removed.

1.6 COORDINATION

A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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 manufacturers specified.
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or comparable product by one of the following.

2.2 CONDUCTORS AND CABLES

A. Available Manufacturers:

2. General Cable Corporation.
4. Alcan Products Corporation; Alcan Cable Division
5. Or Approved Substitute.

B. Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658, Aluminum not permitted.

C. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Types, THHN-THWN, Type XHHW, UF, USE and SO.

D. Multiconductor Cable: Comply with NEMA WC 70 for, Type SO and Type USE with ground wire.

E. MC cable is NOT allowed for branch and feeder wiring.

F. VFC Cable:
   1. Comply with UL 1277, UL 1685, and NFPA 70 for Type TC-ER cable.
   2. Type TC-ER with oversized crosslinked polyethylene insulation, dual spirally wrapped copper tape shields and three bare symmetrically applied ground wires, and sunlight- and oil-resistant outer PVC jacket.
   3. Utilize VFC cable for the entire path of connections from normal power and emergency power to AHU-1 Fan Motor.
   4. VFC cables must be installed in separate conduits, not including any other circuits.

G. Multiwire Branch Circuits: For all multiwire branch circuits, the neutral shall be (1) standard size larger than the ungrounded conductors.

H. 4-Wire Circuits: For all three phase, four wire feeders and branch-circuits, the neutral shall be (1) standard size larger than the ungrounded conductors.

2.3 CONNECTORS AND SPLICES

A. Available Manufacturers:

   1. AFC Cable Systems, Inc.
   3. O-Z/Gedney; EGS Electrical Group LLC.
   4. 3M; Electrical Products Division.
   5. Tyco Electronics Corp.
   6. Or Approved Substitute.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.
2.4 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 and 70B.

2.5 SLEEVES FOR CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.

D. Coordinate sleeve selection and application with selection and application of firestopping as indicated.

2.6 SLEEVE SEALS

A. Available Manufacturers:

1. Advance Products & Systems, Inc.
2. Calpico, Inc.
3. Metraflex Co.
4. Pipeline Seal and Insulator, Inc.
5. Or Approved Substitute.

B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.

1. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.

2. Pressure Plates: Plastic, Carbon steel or Stainless steel. Include two for each sealing element.

3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating or Stainless steel of length required to secure pressure plates to sealing elements.
PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper for feeders of all sizes. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN-THWN, single conductors in raceway.

B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

E. Feeders Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway.

F. Feeders in Cable Tray: Type THHN-THWN, single conductors in raceway.

G. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway.

H. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.

I. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

J. Branch Circuits Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway.

K. Branch Circuits in Cable Tray: Type THHN-THWN, single conductors in raceway.

L. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

M. VFC Output Circuits: Type TC-ER cable with dual tape shield in metal conduit.

N. Class 1 Control Circuits: Type THHN-THWN, in raceway.
O. Class 2 Control Circuits: Type THHN-THWN, in raceway, Power-limited cable, concealed in building finishes or Power-limited tray cable, in cable tray.

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 260533 "Raceway 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.

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 260529 "Hangers and Supports for Electrical Systems."

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.

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.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.5 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "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.
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 260544 "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 as indicated.

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 with the assistance of a factory-authorized service representative:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.


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.

1. Remove and replace any defective cable and re-test as specified above.

END OF SECTION 260519
SECTION 260526 - 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 methods and materials for grounding and bonding systems and equipment, plus the following special applications:
   1. Underground distribution grounding.
   2. Ground bonding common with lightning protection system.
   3. Foundation steel electrodes.

1.3 SUBMITTALS
A. Product Data: For each type of product indicated.
B. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in Part 3 "Field Quality Control" Article, including the following:
   1. Test wells.
   2. Ground rods.
   3. Ground rings.
   4. Grounding arrangements and connections for separately derived systems.
   5. Grounding for sensitive electronic equipment.
C. Qualification Data: For testing agency and testing agency's field supervisor.
D. Field quality-control reports.
E. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals:
   1. Instructions for periodic testing and inspection of grounding features at ground rings and grounding connections for separately derived systems based on NFPA 70B.
a. Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.

b. Include recommended testing intervals.

1.4 QUALITY ASSURANCE

A. 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 to supervise on-sit testing specified in Part 3.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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 manufacturers specified.

3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or comparable product by one of the following.

2.2 MANUFACTURERS

A. Available Manufacturers:

1. Burndy; Part of Hubbell Electrical Systems.
2. Galvan Industries, Inc.; Electrical Products Division, LLC.
4. Or Approved Substitute.
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 UL 467 for grounding and bonding materials and equipment.

2.4 CONDUCTORS

A. Insulated Conductors: Copper or thinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:
   4. Sizes and types of conductors in four subparagraphs below are typical examples. 28-kcmil bonding cable in "Bonding Cable" Subparagraph below is slightly larger than No. 6 AWG.
   5. Bonding Cable: 28-kcmil, 14 strands of No. 17 AWG conductor, 1/4-inch in diameter.
   6. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
   8. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8-inches wide and 1/16-inch thick.

C. Bare Grounding Conductor and Conductor Protector for Wood Poles:
   1. No. 4 AWG minimum, soft-drawn copper.
   2. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.

D. Grounding Bus: Predrilled rectangular bars of annealed copper 1/4- by 4 inches in cross section, unless otherwise indicated; with insulators.

2.5 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory (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, bolted pressure-type, with at least two bolts.
1. Pipe Connectors: Clamp type, sized for pipe.

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 compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.6 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4-inch by 10 feet.

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 stated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0.

   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.

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 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.

3.4 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.
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.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V-ac 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.
3.5 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 260543 "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. 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.

J. 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.

3.6 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: 3 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 260526
SECTION 260533 - 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 1 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.
7. 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.

1.3 DEFINITIONS

A. ARC: Aluminum rigid conduit.
B. EMT: Electrical metallic tubing.
C. ENT: Electrical nonmetallic tubing.
D. EPDM: Ethylene-propylene-diene terpolymer rubber.
E. FMC: Flexible metal conduit.
F. GRC: Galvanized rigid steel conduit.
G. IMC: Intermediate metal conduit.
H. LFMC: Liquidtight flexible metal conduit.
I. LFNC: Liquidtight flexible nonmetallic conduit.
J. NBR: Arcyionitrile-butadiene rubber.

K. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.

1. Custom enclosures and cabinets.
2. For handholes and boxes for underground wiring, including the following:
   a. Duct entry provisions, including locations and duct sizes.
   b. Frame and cover design.
   c. Grounding details.
   d. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
   e. Joint details.

C. Samples for Initial Selection: For wireways, nonmetallic wireways and surface raceways with factory-applied texture and color finishes.

D. Samples for Verification: For each type of exposed finish required for wireways, nonmetallic wireways and surface raceways, prepared on Samples of size indicated below.

E. 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 Engineering features in paths of conduit groups with common supports.

F. Manufacturer Seismic Qualification Certificates: Submit certification that enclosures and cabinets and their mounting provisions, including those for internal components, will withstand seismic forces defined in 260548 "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 cabinet or enclosure will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will retain its enclosure characteristics, including its interior accessibility, 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.
4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.

G. Qualification Data: For professional engineer.

H. Source quality-control reports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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 manufacturers specified.
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or comparable product by one of the following.

2.2 METAL CONDUITS, TUBING, AND FITTINGS

A. Available Manufacturers:

1. AFC Cable Systems, Inc.
2. Alflex Inc.
3. Allied Tube & Conduit; a Tyco International Ltd. Co.
4. Anamet Electrical, Inc; Anaconda Metal Hose
5. Electri-Flex Company.
7. O-Z/Gedney; a unit of General Signal.
8. Picoma Industries.
10. Robroy Industries.
12. Thomas & Betts Corporation.
13. Western Tube and Conduit Corporation.
15. Or Approved Substitute.
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 or IMC.
   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 (Including all Types and Flexible Liquidtight), EMT, and Cable: Comply with NEMA FB 1 and UL 514B; listed for type and size raceway with which used, and for application and environment in which installed.
   1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
   2. Fittings for EMT: Steel or die-cast, set-screw, compression, set-screw or compression type.
   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 Rigid Steel Conduit, IMC, GRC, or ARC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.3 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

A. Available Manufacturers:
   1. AFC Cable Systems, Inc.
   2. Anamet Electrical, Inc.; Anaconda Metal Hose.
   3. Arnco Corporation.
   4. CANTEX Inc.
RIO HONDO COLLEGE  
EMERGENCY GENERATOR AND DATA CENTER HVAC UPGRADES  

7. ElecSYS, Inc. 
8. Electri-Flex Company. 
10. Lamson & Sessions; Carlon Electrical Products. 
11. Manhattan/CDT/Cole-Flex. 
12. Niedax-Kleinhuis USA, Inc. 
13. RACO; a Hubbell Company. 
15. Or Approved Substitute. 

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: Comply with NEMA TC 2 and UL 651, Type EPC-40-PVC, 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." 

2.4 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY AND FITTINGS 

A. Available Manufacturers: 

1. Arnco Corporation. 
2. Endot Industries Inc.
3. IPEX Inc.
4. Lamson & Sessions; Carlon Electrical Products.
5. Or Approved Substitute.

B. Description: Comply with UL 2024; flexible type, approved for plenum, riser and general-use installation.

2.5 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Available Manufacturers:
   1. Cooper B-Line, Inc.
   2. Hoffman.
   4. Square D; Schneider Electric.
   5. Or Approved Substitute.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1, 12 or 3R, 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, Screw-cover type, Flanged-and-gasketed type or as indicated.

E. Finish: Manufacturer's standard enamel finish.

2.6 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

A. Available Manufacturers:
   1. Allied Moulded Products, Inc.
   2. Hoffman.
   3. Lamson & Sessions; Carlon Electrical Products.
   4. Niedax-Kleinhuis USA, Inc.
   5. Or Approved Substitute.

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 size and shape indicated, 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 plastic, extruded and fabricated to size and shape indicated, 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."

2.7 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 Engineer or Prime coated, ready for field painting.

1. Available Manufacturers:
   a. Mono-Systems, Inc.
   b. Panduit Corp.
   c. Thomas & Betts Corporation.
   e. Wiremold Company (The); Electrical Sales Division.
   f. Or Approved Substitute.

C. Surface Nonmetallic Raceways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC with texture and color selected by Engineer from manufacturer's standard colors. Product shall comply with UL 94 V-0 requirements for self-extinguishing characteristics.

1. Available Manufacturers:
   a. Butler Manufacturing Company; Walker Division.
   b. Enduro Systems, Inc.; Composite Products Division.
   c. Hubbell Incorporated; Wiring Device-Kellems Division.
d. Lamson & Sessions; Carlon Electrical Products.
e. Mono-Systems, Inc.
f. Panduit Corp.
g. Walker Systems, Inc.; Wiremold Company (The).
h. Wiremold Company (The); Electrical Sales Division.
i. Or Approved Substitute.

D. Tele-Power Poles:

1. Available Manufacturers:
   a. Mono-Systems, Inc.
   b. Panduit Corp.
   c. Wiremold / Legrand.
   d. Or Approved Substitute.

2. Material: Galvanized steel with ivory baked-enamel finish or 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.

2.8 BOXES, ENCLOSURES, AND CABINETS

A. Available Manufacturers:

1. Adalet.
2. Cooper Crouse-Hinds; Div. of Cooper Industries Inc.
3. EGS/Appleton Electric.
5. FSR Inc.
8. Kraloy.
10. Mono-Systems, Inc.
12. RACO; Hubbell.
14. Spring City Electrical Manufacturing Company.
15. Stahlin Non-Metallic Enclosures.
19. Or Approved Substitute.

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, aluminum, 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 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, round.
   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. 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.

I. 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.

J. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

K. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum or galvanized, cast iron with gasketed cover.

L. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

M. Device Box Dimensions: 4 inches square by 2-1/8-inches deep.

N. Gangable boxes are allowed.

O. 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.
3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

P. 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.

2.9 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. Description: Comply with SCTE 77.
1. Color of Frame and Cover: Gray or Green.
2. Configuration: Units shall be designed for flush burial and have closed or integral 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.”, “TELEPHONE.” as indicated for each service.
6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
7. 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.

C. 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. Available Manufacturers:
D. 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. Available Manufacturers:

   a. Armorcast Products Company.
   b. Carson Industries LLC.
   c. NewBasis.
   d. Nordic Fiberglass, Inc.
   e. Oldcastle Precast, Inc; Christy Concrete Products.
   g. Synertech Moulded Products, Inc.; a division of Oldcastle Precast.
   h. Or Approved Substitute.

2.10 SLEEVES FOR RACEWAYS

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated “wall pipe,” equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.

D. Coordinate sleeve selection and application with selection and application of firestopping.

2.11 SLEEVE SEALS

A. Available Manufacturers:

   1. Advance Products & Systems, Inc.
   2. Calpico, Inc.
   3. Metraflex Co.
   4. Pipeline Seal and Insulator, Inc.
   5. Or Approved Substitute.
B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.

1. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
2. Pressure Plates: Plastic or Carbon steel or Stainless steel. Include two for each sealing element.
3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating or stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.12 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: Rigid steel conduit.
2. Concealed Conduit, Aboveground: Rigid steel conduit, IMC, EMT, RNC, Type EPC-40-PVC.
3. Underground Conduit: RNC, Type EPC-40-PVC or Type EPC-80-PVC, direct buried.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC or LFNC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
6. Application of Handholes and Boxes for Underground Wiring:

   a. Handholes and Pull Boxes in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete or Fiberglass enclosures with
polymer-concrete frame and cover or Fiberglass-reinforced polyester resin, SCTE 77, Tier 15 structural load rating.

b. Handholes and Pull Boxes in Sidewalk and Similar Application with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer-concrete units or heavy-duty fiberglass units with polymer-concrete frame and cover, SCTE 77, Tier 8 structural load rating.

c. Handholes and Pull Boxes Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin structurally tested according to SCTE 77 with 3000-lbf vertical loading.

B. Comply with following indoor applications, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT or ENT 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: Rigid steel conduit. Includes raceways in the following locations:
   a. Loading dock.
   b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
   c. Mechanical rooms.
   d. Gymnasiums.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT or ENT or RNC, Type EPC-40-PVC.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: Rigid steel conduit.
7. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: Riser-type, optical fiber/communications cable raceway or EMT.
8. Raceways for Concealed General Purpose distribution of Optical Fiber or Communications Cable: General-use, optical fiber/communications cable raceway or riser-type, optical fiber/communications cable raceway or Plenum-type, optical fiber/communications cable raceway or EMT.
9. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel or nonmetallic in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

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 setscrew, steel or 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 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 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-foot intervals.
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 Engineer for each specific location.
5. Change from ENT to RNC, Type EPC-40-PVC, rigid steel conduit, or IMC before rising above floor.

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-inch radius 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. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:

1. 3/4-Inch Trade Size and Smaller: Install raceways in maximum lengths of 50 feet.
2. 1-Inch Trade Size and Larger: Install raceways in maximum lengths of 75 feet.
3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway 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.

U. 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 at the following points:

V. 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.

W. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

X. Expansion-Joint Fittings for RNC:

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 and EMT 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.

d. Attics: 135 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.

Y. 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.

Z. 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.

AA. 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.

BB. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

CC. Locate boxes so that cover or plate will not span different building finishes.

DD. 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.

EE. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

FF. Set metal floor boxes level and flush with finished floor surface.
GG. 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 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 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 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 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 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 handholes with bottom below frost line, as per site requirement 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 INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Rectangular Sleeve Minimum Metal Thickness:
   1. For sleeve cross-section rectangle perimeter less than 50 inches and no side greater than 60 inches thickness shall be 0.052 inch.
   2. For sleeve cross-section rectangle perimeter approved substitute to, or greater than, 50 inches and 1 or more sides approved substitute to, or greater than, 16 inches thickness shall be 0.138 inch.

E. Fire-Rate Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless opening compatible with firestop system used are fabricated during construction of floor or wall.

F. Cut sleeves to length for mounting flush with both surfaces of walls.

G. Extend sleeves installed in floors 2 inches above finished floor level.

H. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway unless sleeve seal is to be installed or unless seismic criteria require different clearance.
I. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to 079213 “Elastomeric Joint Sealants” for materials and installation.

K. Fire-Rated Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves with seal and firestop materials.

L. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.

M. Aboveground, Exterior-Wall Penetrations: Seal penetrations using 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.

N. Underground, Exterior-Wall Penetrations: Install cast-iron “wall pipes” for sleeves. Size sleeves to allow for 1-inch annular clear space between raceway and sleeve for installing mechanical sleeve seals.

3.6 SLEEVE-SEAL INSTALLATION

A. Install to seal underground, exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.7 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies.

3.8 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 260533
SECTION 260543 - 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 1 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.

1.3 DEFINITIONS

A. RNC: Rigid nonmetallic conduit.
B. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.4 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 or Step 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.

C. 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.

D. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.

E. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.

F. Source quality-control reports.

G. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

B. Comply with ANSI C2.

C. Comply with NFPA 70.

1.6 DELIVER, STORAGE, AND HANDLING

A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.
B. Store precast concrete and other factory-fabricated underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

C. Lift and support precast concrete units only at designated lifting or supporting points.

1.7 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 Engineer, Construction Manager, and Owner no fewer than two days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Engineer's, Construction Manager's, Owner'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.

1.8 COORDINATION

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.

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 from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Engineer.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Furnish cable-support stanchions, arms, insulators, and associated fasteners in quantities equal to 5 percent of quantity of each item installed.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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 manufacturers specified.
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or comparable product by one of the following.

2.2 GENERAL REQUIREMENTS FOR DUCTS AND RACEWAYS

A. Comply with ANSI C2.

2.3 CONDUIT


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.

2.4 NONMETALLIC DUCTS AND DUCT ACCESSORIES

A. Available Manufacturers:

1. ARNCO Corp.
2. Beck Manufacturing.
3. Cantex, Inc.
6. ElecSys, Inc.
7. Electri-Flex Company.
8. IPEX Inc.
9. Lamson & Sessions; Carlon Electrical Products.
10. Manhattan/CDT; a division of Cable Design Technologies.
11. Spiraduct/AFC Cable Systems, Inc.
12. Or Approved Substitute.
B. Underground Plastic Utilities Duct: NEMA TC 6 & 8, ASTM F 512, UL 651A, Type EB-20-PVC, with matching fittings complying with NEMA TC 9 by same manufacturer as the duct.

C. 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.

D. 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.
   3. Concrete Warning Planks: Nominal 12 by 24 by 3 inches in size, manufactured from 6000-psi concrete.
      b. Mark each plank with "ELECTRIC" in 2-inch-high, 3/8-inch-deep letters.

2.5 PRECAST CONCRETE HANDHOLES AND BOXES

A. Available Manufacturers:
   1. Carder Concrete Products.
   2. Christy Concrete Products.
   3. Elmhurst-Chicago Stone Co.
   5. Rinker Group, Ltd.
   6. Riverton Concrete Products; a division of Cretex Companies, Inc.
   7. Utility Concrete Products, LLC.
   8. Utility Vault Co.
   9. Wausau Tile Inc.
   10. Or Approved Substitute.

B. Comply with ASTM C 858 for design and manufacturing processes.

C. 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.", "TELEPHONE." Or as indicated for each service.

7. Configuration: Units shall be designed for flush burial and have closed or integral 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. 4 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.

2.6 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 or Green.
2. Configuration: Units shall be designed for flush burial and have closed or integral 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.", "TELEPHONE" or as indicated for each service.
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.
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. Available Manufacturers:
   a. Armorcast Products Company.
   b. Carson Industries LLC.
   c. CDR Systems Corporation.
   d. NewBasis.
   e. Quazite: Hubbell Power System, Inc.
   f. Or Approved Substitute.

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. Available Manufacturers:
   a. Armorcast Products Company.
D. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers of fiberglass.

1. Available Manufacturers:
   a. Carson Industries LLC.
   b. Christy Concrete Products.
   c. Nordic Fiberglass, Inc.
   e. Synertech Moulded Products, Inc.; a division of Oldcastle Precast.
   f. Or Approved Substitute.

E. High-Density Plastic Boxes: Injection molded of high-density polyethylene or copolymer-polypropylene. Cover shall be of plastic.

1. Available Manufacturers:
   a. Carson Industries LLC.
   b. Nordic Fiberglass, Inc.
   c. PenCell Plastics.
   e. Or Approved Substitute.

2.7 PRECAST MANHOLES

A. Available Manufacturers:

1. Carder Concrete Products.
2. Christy Concrete Products.
3. Elmhurst-Chicago Stone Co.
5. Rinker Group, Ltd.
6. Riverton Concrete Products.; a division of Cretex Companies, Inc.
7. Utility Concrete Products, LLC.
8. Utility Vault Co.
9. Wausau Tile Inc.
10. Or Approved Substitute.

B. Comply with ASTM C 858, with structural design loading as specified in “Underground Enclosure Application” Article and with interlocking mating sections, complete with accessories, hardware, and features.
1. **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 roofs of manholes, 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.
   
2. **Duct Entrances in Manhole 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 manholes to facilitate racking of cable.
   
C. **Concrete Knockout Panels:** 1-1/2- to 2 inches thick, for future conduit entrance and sleeve for ground rod.
   
D. **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.
   
E. **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.

2.8 **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.

C. **Structural Design Loading:** As specified in "Underground Enclosure Application" Article.

2.9 **UTILITY STRUCTURE ACCESSORIES**

A. **Available Manufacturers:**

1. Bilco Company (The).
2. Campbell Foundry Company.
3. Carder Concrete Products.
4. Christy Concrete Products.
5. East Jordan Iron Works, Inc.
7. McKinley Iron Works, Inc.
14. Rinker Group, Ltd.
15. Riverton Concrete Products.; a division of Cretex Companies, Inc.
17. Utility Concrete Products, LLC.
18. Utility Vault Co.
19. Wausau Tile Inc.
20. Or Approved Substitute.

B. 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 or cast aluminum with milled cover-to-frame bearing surfaces; diameter, 26 inches or 29 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.
   c. Legend: “SIGNAL” for communications, data, and telephone duct systems.

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.
C. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.

D. 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.

E. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch-diameter eye, rated 2500-lbf> minimum tension.

F. 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.

G. 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.

H. 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.

I. 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.

J. Cable Rack Assembly: Steel, hot-rolled or hot-dip 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.

   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.

L. 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.

M. Fixed Manhole Ladders: Arranged for attachment to roof or wall and floor of manhole. Ladder and mounting brackets and braces shall be fabricated from nonconductive, structural-grade, fiberglass-reinforced resin or hot-dip galvanized steel.

N. Portable Manhole Ladders: UL-listed, heavy-duty wood or 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.

O. Cover Hooks: Heavy duty, designed for lifts 60 lbf and greater or Light duty, designed for lifts less than 60 lbf. Two required.

2.10 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 311000 "Site Clearing." Remove and stockpile topsoil for reapplication according to Section 311000 "Site Clearing."

3.2 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical Cables More than 600 V: RNC, NEMA Type EPC-40-PVC, in concrete-encased duct bank unless otherwise indicated.

B. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40-PVC, in concrete-encased duct bank unless otherwise indicated.

C. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-80-PVC, in direct-buried duct bank unless otherwise indicated.

D. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-80-PVC, in direct-buried duct bank unless otherwise indicated.

E. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40-PVC, in concrete-encased duct bank, unless otherwise indicated.

F. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40-PVC, in direct-buried or concrete-encased duct bank, unless otherwise indicated.

G. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank, unless otherwise indicated.

H. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EB-20-PVC, in concrete-encased duct bank, unless otherwise indicated.

I. Underground Ducts Crossing Paved Paths, Walks and Driveways or 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 or H-20 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, Polymer concrete, SCTE 77, Tier 15, Fiberglass enclosures with polymer concrete frame and cover, SCTE 77, Tier 15 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, Polymer concrete units, SCTE 77, Tier 8 or Heavy-duty fiberglass units with polymer concrete frame and cover, SCTE 77, Tier 8 structural load rating.
4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin or High-density plastic, 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 312000 "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.

D. Cut and patch existing pavement in the path of underground ducts and utility structures according as specified.

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 104 deg F. Where environmental temperatures are calculated to rise above 104 deg F, 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 260544 "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 312000 "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 5 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: Spade 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. Use a plank to direct concrete down sides of bank assembly to trench bottom. 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.

15. Stub-Ups: Use manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Extend concrete encasement throughout the length of the elbow.

16. Stub-Ups: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

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.

17. 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 the centerline of duct bank. Provide additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

K. Direct-Buried Duct Banks:

1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.

2. Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 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.

3. Excavate trench bottom to provide firm and uniform support for duct bank. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches in nominal diameter.

4. Set elevation of bottom of duct bank below frost line.
5. 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.

6. Install backfill as specified in Section 321000 “Earth Moving”.

7. 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 312000 "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.

8. Install ducts with a minimum of 3 inches between ducts for like services and 6 inches between power and signal ducts.

9. Depth: Install top of duct bank at least 36 inches below finished grade unless otherwise indicated.

10. 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.

11. 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.

12. 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 for cast-in-place concrete, formwork, and reinforcement as specified.

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. Install handholes with bottom below frost line, as site required below grade.
4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
5. 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 and handholes after concrete has cured at least three days. 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 and handholes after concrete has cured at least three days. 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, and cable arms, and insulators, 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.

K. Warning Sign: Install “Confined Space Hazard” warning sign on the inside surface of each manhole cover.

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 handholes and boxes with bottom below frost line, as per site requirement 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 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.

G. For enclosures installed in asphalt paving and as per College standard 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, 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 260526 "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 260526 "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 260543
SECTION 260544 - 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 1 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.
5. Silicone sealants.

B. Related Requirements:

1. All contract documents.

1.3 SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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 manufacturers specified.
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or comparable product by one of the following.
2.2 SLEEVES

A. Wall Sleeves:
   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:
   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.

2.3 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

   1. Available Manufacturers:
      a. Advance Products & Systems, Inc.
      b. CALPICO, Inc.
      c. Metraflex Company (The).
      d. Pipeline Seal and Insulator, Inc.
      e. Proco Products, Inc.
      f. Or Approved Substitute.

   2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

   3. Pressure Plates: Carbon steel.
4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

2.4 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. Available Manufacturers:
   a. Presealed Systems.
   b. Or Approved Substitute.

2.5 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.


C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.6 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.
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.
      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 sleeved 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 260544
SECTION 260548 – VIBRATION AND SEISMIC 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

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 Requirements:

1. Section 260500 “Common Work Results for Electrical.”
2. Section 260529 “Hangers and Supports for Electrical Systems.”

1.3 DEFINITIONS

A. The IBC: International Building code


C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 PERFORMANCE REQUIREMENTS

A. Refer to Structural drawings for seismic forces specific to this project.

B. Unit Substations shall be mounted on Type E Neoprene Isolators with static deflection of 0.15 inches and appropriate seismic restraints.

C. Distribution Panels connected to transformers and Unit Substations shall be mounted on Type E Neoprene Isolators with static deflection of 0.15 inches.
static deflection. Distribution panels shall be floor-mounted and connected to adjacent transformers within buildings by flexible conduit.

D. For suspended raceways between Unit Substations and Distribution Panels, Type F Isolation Hangers with 0.1 inch deflection and the appropriate seismic restraint shall be used, within the Unit Substation electrical equipment room only.

1.5 SUBMITTALS

A. Product Data: For each type of product.
   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.
      a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction.
      b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Design Calculations: Calculate static and dynamic loading caused by equipment weight, operation, and seismic forces required to select seismic restraints and for designing vibration isolation bases.
      a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
   2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
   3. Field- Fabricated supports.
   4. Seismic-Restraint Details:
      a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
      b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show
attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

d. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

D. Qualification Data: For professional engineer and testing agency.

E. Welding certificates.

F. Field quality-control 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 Qualifications: 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. They shall bear anchorage preapproval from OSHPD in addition to preapproval, showing maximum seismic-restraint ratings, by ICC-ES or another agency acceptable to authorities having jurisdiction. 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) that support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

E. Comply with NFPA 70.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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 manufacturers specified.
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or comparable product by one of the following.

2.2 VIBRATION ISOLATORS

A. Available Manufacturers:

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
4. Isolation Technology, Inc.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
10. Or Approved Substitute.

B. Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant neoprene, rubber or hermetically sealed compressed fiberglass.

C. 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.

D. 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.

2.3 SEISMIC-RESTRAINT DEVICES

A. Available Manufacturers:

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Cooper B-Line, Inc.; a division of Cooper Industries.
4. Hilti Inc.
5. Loos & Co.; Seismic Earthquake Division.
6. Mason Industries
7. TOLCO Incorporated; a brand of NIBCO INC.
8. Unistrut; Tyco International, Ltd.
9. Or Approved Substitute.

B. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and...
other matching components and with corrosion resistant coating; and rated in tension, compression, and torsion forces.

D. Restraint Cables: ASTM A 603 galvanized or ASTM A 492 stainless-steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod. Do not weld stiffeners to rods.

F. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.

G. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices.

H. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

I. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

J. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.4 FACTORY FINISHES

A. Finish: Manufacturer’s standard prime-coat finish read 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 of the Work.

B. Examine roughing-in for 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 evaluation service member of ICC-ES or 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 caused by 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. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork as specified.

B. Equipment and Hanger Restraints:

1. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

2. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction providing required submittals for component.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. 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.
E. 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.

F. 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 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform the following 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.

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.
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.

C. Seismic controls will be considered defective if they do not pass tests and inspections.

D. Remove and replace malfunctioning units and retest as specified.

E. Prepare test and inspection reports.

3.6 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 260548
SECTION 260553 - 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Identification for raceway and metal-clad cable.
2. Identification for conductors and communication and control cable.
4. Warning labels and signs.
5. Instruction signs.
7. Miscellaneous identification products.

1.3 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

C. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

1.4 QUALITY ASSURANCE


B. Comply with NFPA 70.


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.
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 Raceway-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 raceway size.

B. Colors for Raceways Carrying Circuits at 600 V or Less:
   1. Power Circuits: Black letters on an orange field.
   2. Legend: Indicate system or service and voltage, if applicable.

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. Self-Adhesive 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. Snap-Around Labels: 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: 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. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded.
2.2 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE 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. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

C. Aluminum Wraparound Marker Labels: Cut from 0.014-inch-thick aluminum sheet, with stamped, embossed, or scribed legend, and fitted with tabs and matching slots for permanently securing around wire or cable jacket or around groups of conductors.

D. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend punched for use with self-locking nylon tie fastener.

E. Write-On Tags: Polyester tag, 0.010 inch or 0.015 inch thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

2.3 UNDERGROUND-LINE WARNING TAPE

A. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.
   1. Not less than 6 inches wide by 4 mils thick.
   2. Compounded for permanent direct-burial service.
   3. Embedded continuous metallic strip or core.
   4. Printed legend shall indicate type of underground line.

2.4 WARNING LABELS AND SIGNS


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."

2.5 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.

2.6 EQUIPMENT IDENTIFICATION LABELS

A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

B. 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.


E. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.
2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, Type 6/6 nylon.
   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.

B. Paint:
   1. Exterior Concrete, Stucco, and Masonry:
      a. Semi-gloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
         1) Primer: Exterior concrete and masonry primer.
   2. Exterior Concrete Unit Masonry:
      a. Semi-gloss Acrylic-Enamel Finish: Two finish coat(s) over a block filler.
         1) Block Filler: Concrete unit masonry block filler.
   3. Exterior Ferrous Metal:
      a. Semi-gloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
         1) Primer: Exterior ferrous-metal primer.
         2) Finish Coats: Exterior semi-gloss alkyd enamel.
   4. Exterior Zinc-Coated Metal (except Raceways):
      a. Semi-gloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
         1) Primer: Exterior zinc-coated metal primer.
         2) Finish coats: Exterior semi-gloss alkyd enamel.
   5. Interior Concrete and Masonry (Other Than Concrete Unit Masonry):
      a. Semi-gloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
         1) Primer: Interior concrete and masonry primer.
         2) Finish Coats: Interior semi-gloss alkyd enamel.
   6. Interior Concrete Unit Masonry:
IDENTIFICATION FOR ELECTRICAL SYSTEMS

7. Interior Gypsum Board:
   a. Semi-gloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
      1) Primer: Interior gypsum board primer.
      2) Finish Coats: Interior semi-gloss acrylic enamel.

8. Interior Ferrous Metal:
   a. Semi-gloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
      1) Primer: Interior ferrous-metal primer.
      2) Finish Coats: Interior semi-gloss acrylic enamel.

9. Interior Zinc-Coated Metal (except Raceways):
   a. Semi-gloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
      1) Primer: Interior zinc-coated metal primer.
      2) Finish Coats: Interior semi-gloss acrylic enamel.

C. 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 IDENTIFICATION SCHEDULE

A. Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch-wide black stripes on 10-inch centers over orange background that extends full length of raceway or duct and is 12 inches wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE Wiring" with 3-inch-high black letters on 20-inch centers. Stop stripes at legends. Apply to the following finished surfaces:

1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
2. Wall surfaces directly external to raceways concealed within wall.
3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
B. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Identify with "DANGER-HIGH VOLTAGE" in black letters at least 2 inches high, with self-adhesive vinyl or snap-around labels. Install labels at 10-foot maximum intervals.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30A: Identify with orange self-adhesive vinyl label, snap-around label, or self-adhesive vinyl tape applied in bands. Install labels at 10-foot maximum intervals.

D. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with color-coded, self-adhesive tape applied in bands or snap-around, color-coding bands:

1. Fire Alarm System: Red.
5. Mechanical and Electrical Supervisory System: Green and blue.
7. Control Wiring: Green and red.

E. Power-Circuit Conductor Identification: For primary and secondary conductors No. 1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes use color-coding conductor tape, marker tape, or aluminum wraparound marker labels. Identify source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.

F. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use color-coding conductor tape, marker tape or aluminum wraparound marker labels. Identify each ungrounded conductor according to source and circuit number.

G. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source and circuit number.


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.

I. 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.

J. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels, Baked-enamel warning signs or Metal-backed, butyrate warning signs. Identify system with black letters on an orange background. Apply to exterior of door, cover, or other access.

1. 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.

2. 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.

K. Instruction Signs:

1. Operating Instructions: 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.
2. Emergency Operating Instructions: 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 or load shedding.

L. 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: Engraved, laminated acrylic or melamine label. 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: Engraved, laminated acrylic or melamine label, 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. Switchgear.
   e. Switchboards.
   f. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
   g. Electrical Substations.
   h. Emergency system boxes and enclosures.
   i. Motor-control centers.
   j. Disconnect switches.
   k. Enclosed circuit breakers.
   l. Enclosed controllers.
   m. Variable-speed controllers.
   n. Motor starters.
   o. Push-button stations.
   p. Power transfer equipment.
   q. Contactors.
   r. Remote-controlled switches, dimmer modules, and control devices.
   s. Battery-inverter units.
   t. Battery racks.
   u. Power-generating units.
   v. Voice and data cable terminal equipment.
   w. Master clock and program equipment.
   x. Intercommunication and call system master and staff stations.
   y. Television/audio components, racks, and controls.
   z. Fire-alarm control panel and annunciators.
   aa. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks.
   bb. Monitoring and control equipment.
   cc. UPS equipment.
   dd. Terminals, racks, and patch panels for voice and data communication and for signal and control functions.

3.2 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. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

F. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape with adhesive appropriate to the location and substrate.

G. 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.

H. Color-Coding for Phase and Voltage Level Identification, 600 V-ac and Less: Use the colors listed below for service, feeder, and branch-circuit conductors.

1. Color shall be factory applied or, for sizes larger than No. 10 AWG if authorities having jurisdiction permit, field applied.
2. Colors for 208/120-V-ac Circuits:
   a. Phase A: Black.
   b. Phase B: Red.
   c. Phase C: Blue.
   e. Ground: Green.

3. Colors for 480/277-V-ac Circuits:
   b. Phase B: Orange.
   c. Phase C: Yellow.
   e. Ground: Green.

4. 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.

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 for surface preparation and paint application as specified.

END OF SECTION 260553
SECTION 260913 - ELECTRICAL POWER MONITORING AND CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes the following for monitoring and control of electrical power system:
   1. PC-based workstation(s) and software.
   2. Communication network and interface modules for RS-232 or RS-485, Modbus TCP/IP or IEEE 802.3 data transmission protocols.

B. Related Sections:
   1. Section 262713 "Electricity Metering" for equipment to meter electricity consumption and demand for tenant submetering.

1.3 DEFINITIONS

A. Ethernet: Local area network based on IEEE 802.3 standards.

B. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.

C. HTML: Hypertext markup language.

D. I/O: Input/output.

E. KB: Short for kilobyte. When used to describe data storage, "KB" represents 1024 bytes.

F. KY Pulse: A term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay changing status in response to the rotation of the disk in the meter.

G. LAN: Local area network; sometimes plural as "LANs."

H. LCD: Liquid crystal display.
I. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or remote-control, signaling and power-limited circuits.

J. Modbus TCP/IP: An open protocol for exchange of process data.

K. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

L. PC: Personal computer; sometimes plural as "PCs."

M. rms: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.


P. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

Q. THD: Total harmonic distortion.

R. UPS: Uninterruptible power supply; used both in singular and plural context.

S. WAN: Wide area network.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.
   1. Attach copies of approved Product Data submittals for products (such as switchboards and switchgear) that describe power monitoring and control features to illustrate coordination among related equipment and power monitoring and control.

B. Shop Drawings: For power monitoring and control equipment. Include plans, elevations, sections, details, and attachments to other work.
   1. Outline Drawings: Indicate arrangement of components and clearance and access requirements.
   2. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
   3. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Wiring Diagrams: For power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
5. UPS sizing calculations for workstation.
6. Surge Suppressors: Data for each device used and where applied.

C. Software and Firmware Operational Documentation:
   1. Self-study guide describing the process for setting equipment's network address; setting Owner's options; procedures to ensure data access from any PC on the network, using a standard Web browser; and recommended firewall setup.
   2. Software operating and upgrade manuals.
   3. Software Backup: On a magnetic media or compact disc, complete with Owner-selected options.
   4. Device address list and the set point of each device and operator option, as set in applications software.
   5. Graphic file and printout of graphic screens and related icons, with legend.

D. Software Upgrade Kit: For Owner to use in modifying software to suit future power system revisions or power monitoring and control revisions.

E. Software licenses and upgrades required by and installed for operating and programming digital and analog devices.

F. Qualification Data: For qualified Installer and manufacturer.

G. Field quality-control reports.

H. Operation and Maintenance Data: For power monitoring and control units, to include in emergency, operation, and maintenance manuals. Include the following:
   1. Operating and applications software documentation.
   2. Software licenses.
   3. Software service agreement.
   4. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Software shall include system restore, emergency boot diskettes, and drivers for all installed hardware. Provide separately for each PC.
   5. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy submittal.

I. Other Informational Submittals:
   1. Manufacturer's system installation and setup guides, with data forms to plan and record options and setup decisions.
1.5 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Manufacturer Qualifications: A firm experienced in manufacturing power monitoring and control equipment similar to that indicated for this Project and with a record of successful in-service performance.

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

1.6 COORDINATION

A. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.


B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

1.7 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for two years.

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

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

1.8 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Addressable Relays: One for every 10 installed. Furnish at least one of each type.
2. Data Line Surge Suppressors: One for every 10 of each type installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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 manufacturers specified.
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or comparable product by one of the following.

2.2 MANUFACTURERS

A. Available Manufacturers:

1. Allen-Bradley; Rockweel Automation.
2. Cutler Hammer Group; Eaton Electrical Inc.
4. Landis+Gyr Inc.
7. Or Approved Substitute.

2.3 ENERGY MONITORING

A. Individual Building energy monitoring systems consist of a Commodities Panel housing a power system monitor (ION-7300/7350) and two utility metering flow computer(s) (KEP ES-749) for steam and chilled water flow and BTU monitoring. Each KEP computer provides 24 V-dc power for required field instrumentation. They have multiple calculations for steam, water, air and natural gas available. They also include additional capabilities, such as steam trap monitoring. Finally, they provide peak demand calculations, internal data logging and local, non-resettable (password protected) BTU totalizer displays.

2.4 COMMODITIES PANEL

A. The Commodities Panel shall be a 20 by 16 by 10 NEMA 4/12 (IEC IP 66) rated enclosure. It should be located in a clean, dry, low vibration area with easy
access. The panel will be built with panel mounted Ion power systems monitor and 2 KEP computers: for chilled water and steam energy. The panel will be pre-wired for two spare analog inputs via an analog to Modbus module for easy of other commodities, such as domestic water and/or natural gas. The panel will be supplied with 120 V-ac, and provide fused protection. PT and CT connections, to the ION monitor will utilize fused and shorting block terminations. A 24 V-dc power supply will power the KEP computers, a protocol translator gateway and required I/O loads. A bulkhead RJ45 connector will provide easy connection to the building’s Ethernet network. DIN rail mounting shall be utilized and include room for future growth or modifications.

2.5 FUNCTIONAL DESCRIPTION

A. Instrumentation and Recording Devices: Monitor and record load profiles and chart energy consumption patterns.

1. Calculate and Record the Following:
   a. Load factor.
   b. Peak demand periods.
   c. Consumption correlated with facility activities.

2. Measure and Record Metering Data for the Following:
   a. Electricity.
   b. Domestic water.
   c. Natural gas.
   d. Chilled water flow.

B. Software: Calculate allocation of utility costs.

1. Automatically Import Energy Usage Records to Allocate Energy Costs for the Following:
   a. At least 15 departments.
   b. At least 30 tenants.
   c. At least five processes.
   d. At least one building.

C. Power Quality Monitoring: Identify power system anomalies and measure, display, and record trends and alarms of the following power quality parameters:

1. Voltage regulation and unbalance.
2. Continuous three-phase rms voltage.
3. Periodic max./min./avg. voltage samples.
4. Harmonics.
5. Voltage excursions.
D. Emergency Load Shedding. Preserve critical loads or avoid total shutdown due to unforeseen loss of power sources according to the following logic:

1. Determine system topology.
2. Evaluate remaining loads and sources.
3. Shed loads in less than 100 ms.

E. Demand Management:

1. Peaking or co-generator control.
2. Load interlocking.
3. Load shedding.
4. Load trimming.

F. System: Report equipment status and power system control.

G. Process Instrumentation: The KEP flow computer is capable of handling multiple process inputs, but the following standards should apply to any device selected:

1. General transmitter specifications:
   b. Output: Analog (4 to 20 mA).
   d. Flow: In-line vortex, orifice plate or magnetic sensors shall be used for steam/gas flow. Other flow methods (turbine) may also be used for water, as applicable for the application. All volumetric flow devices shall be properly sized to obtain an accuracy of plus or minus 1 percent of reading, or better. Mass flow systems shall obtain a total accuracy of plus or minus 1.5 percent.
   e. Temperature: RTD’s shall be used for steam/gas density compensation and BTU calculations. High accuracy (0.1 percent at 32 deg F) 100 ohm PT 3-wire RTD’s, spring-loaded in thermowells, are required.
   f. Pressure: Pressure transmitters, required for gas density compensation, shall have an accuracy of plus or minus 0.25 percent of span, or better.

H. Specifications:

1. Accuracy:
      1) Sensor Type: Vortex/Orifice.
      2) Volumetric: Plus or minus 1 percent of reading.
      3) Mass: Plus or minus 1.5 percent of reading.
1. Sensor Type: Turbine.
2. Volumetric: Plus or minus 1 percent of reading.

1. Sensor Type: Magnetic.
2. Mass: Plus or minus 1.5 percent of reading.

1. Sensor type: 100 ohm PT 3-wire RTD.
2. General: Plus or minus 0.1 percent at 32 deg F.

e. Measurement: Pressure.
1. Silicon filed 316SS.
2. Plus or minus 0.25 percent of span.

2. Wiring:

a. Voltage: 120 V-ac.
   1. Minimum Sizing: 14 AWG.
   2. Wire Type: THWN or THHN.

b. Voltage: 24 V-dc.
   1. Minimum Sizing: 18 AWG.
   2. Wire Type: THWN or THHN.

I. Steam Flow Meter:

1. Building steam flow meters must be sized to provide accurate readings for expected flowing conditions. Reduced pipe meter runs must be used when required to achieve proper flow velocity. No meter will be installed on systems with 3/4 inch, or less pipe size.

2. Volumetric flow output will provide input to a KEP ES-749 Utility Flow Computer. Density compensation will be provided via a 3-wire RTD input to the KEP. The RTD must be spring-loaded in a thermal well. It must be mounted in accordance with flow meter and RTD manufacturer’s recommendations for proper operation. Accuracy must meet or exceed 0.1 percent at 32 deg F.

3. The KEP Utility Flow Computer will provide corrected readings for Mass Flow and Energy Rate. These readings will be made available to the Energy Monitoring Server.

4. Steam Flow Meter Specification Details:
   a. Accuracy: 1 percent of rate.
   b. Repeatability: 0.1 percent of rate.
2.6 SYSTEM REQUIREMENTS

A. Monitoring and Control System: Include PC-based workstation or multiple PC-based workstations and multiple PC-based workstations with graphics capability and Web access, with its operating system and application software, connected to data transmission network.

B. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.

1. Minimum Protection for Power Lines 120 V-ac and More: Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."

2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements as recommended by manufacturer for type of line being protected.

C. Addressable Devices: All transmitters and receivers shall communicate unique device identification and status reports to monitoring and control clients.

D. BAS Interface: Provide factory-installed hardware and software to enable the BAS to monitor, display, and record data for use in processing reports.

1. Hardwired Monitoring Points: Electrical power demand (kilowatts), electrical power consumption (kilowatt-hours), power factor.

2. ASHRAE 135 (BACnet), Modbus, or Industry-accepted, open-protocol communication interface with the BAS shall enable the BAS operator to remotely monitor meter information from a BAS operator workstation. Control features and monitoring points displayed locally at metering panel shall be available through the BAS.

2.7 OPERATING SYSTEM

A. Software: Configured to run on a portable laptop computer, a single PC, or a palm computer, with capability for accessing a single meter at a time. System is not connected to a LAN. Modbus TCP/IP, RS-232, and RS-485 digital communications.


D. Software: Configured for a server and multiple client PCs, each with capability for accessing multiple devices simultaneously. Software shall include interactive graphics client and shall be Web enabled. Workstations and portable computers shall not require any software except for an Internet browser to provide connectivity and full functionality. Include a firewall recommended by manufacturer. 100 Base-T Ethernet, Modbus TCP/IP RS-232, and RS-485 digital communications.

E. Operating System Software: Based on 32-bit, Microsoft Windows workstation operating system. Software shall have the following features:

1. Multiuser and multitasking to allow independent activities and monitoring to occur simultaneously at different workstations.
2. Graphical user interface to show pull-down menus and a menu tree format.
3. Capability for future additions within the indicated system size limits.

F. Peer Computer Control Software: Shall detect a failure of workstation and associated server, and shall cause other workstation and associated server to assume control of all system functions without interruption of operation. Drivers shall be provided in both central computers to support this mode of operation.

2.8 APPLICATIONS SOFTWARE

A. Basic Requirements:

1. Fully compatible with and based on the approved operating system.
2. Password-protected operator login and access; three levels, minimum.
5. Capability of creating, deleting, and copying files; and automatically maintaining a directory of all files, including size and location of each sequential and random-ordered record.
6. Capability for importing custom icons into graphic views to represent alarms and I/O devices.
7. Automatic and encrypted backups for database and history; automatically stored at central control PC or selected workstation and encrypted with a nine-character alphanumeric password, which must be used to restore or read data contained in backup.
8. Operator audit trail for recording and reporting all changes made to user-defined system options.
B. Workstation Server Functions:
   1. Support other client PCs on the LAN and WAN.
   2. Maintain recorded data in databases accessible from other PCs on the LAN and WAN.

C. Data Formats:
   1. User-programmable export and import of data to and from commonly used Microsoft Windows spreadsheet, database, billing, and other applications; using dynamic data exchange technology.
   2. Option to convert reports and graphics to HTML format.
   3. Interactive graphics.
   4. Option to send preprogrammed or operator designed e-mail reports.

D. Metered Data: Display metered values in real time.

E. Remote Control:
   1. Display circuit-breaker status and allow breaker control.
   2. User defined with load-shedding automatically initiated and executed schemes responding to programmed time schedules, set points of metered demands, utility contracted load shedding, or combinations of these.

F. Equipment Documentation: Database for recording of equipment ratings and characteristics; with capability for graphic display on monitors.

G. Graphics: Interactive color-graphics platform with pull-down menus and mouse-driven generation of power system graphics, in formats widely used for such drafting; to include the following:
   1. Site plan.
   2. Floor plans.
   3. Equipment elevations.

H. User-Defined Monitoring and Control Events: Display and record with date and time stamps accurate to 0.1 second, and including the following:
   1. Operator log on/off.
   2. Attempted operator log on/off.
   3. All alarms.
   4. Equipment operation counters.
   5. Out-of-limit, pickup, trip, and no-response events.

I. Trending Reports: Display data acquired in real-time from different meters or devices, in historical format over user-defined time; unlimited as to interval, duration, or quantity of trends.
1. Spreadsheet functions of sum, delta, percent, average, mean, standard deviation, and related functions applied to recorded data.
2. Charting, statistical, and display functions of standard Windows-based spreadsheet.

J. Alarms: Display and record alarm messages from discrete input and controls outputs, according to user programmable protocol.

1. Functions requiring user acknowledgment shall run in background during computer use for other applications and override other presentations when they occur.

K. Waveform Data: Display and record waveforms on demand or automatically on an alarm or programmed event. Include the graphic displays of the following, based on user-specified criteria:

1. Phase voltages, phase currents, and residual current.
2. Overlay of three-phase currents, and overlay each phase voltage and current.
3. Waveforms ranging in length from 2 cycles to 5 minutes.
4. Disturbance and steady-state waveforms up to 512 points per cycle.
5. Transient waveforms up to 83,333 points per cycle on 60-Hz base.
6. Calculated waveform, based on recorded data, on a minimum of four cycles of data of the following:
   a. THD.
   b. rms magnitudes.
   c. Peak values.
   d. Crest factors.
   e. Magnitude of individual harmonics.

L. Data Sharing: Allow export of recorded displays and tabular data to third-party applications software.

1. Tabular data shall be in the comma-separated values.

M. Activity Billing Software:

1. Automatically compute and prepare activity demand and energy-use statements based on metering of energy use and peak demand integrated over user-defined interval.
2. Intervals shall be same as used by electric utilities, including current vendor.
3. Import metered data from saved records that were generated by metering and monitoring software.
4. Maintain separate directory for each activity's historical billing information.
5. Prepare summary reports in user-defined formats and time intervals.

N. Reporting: User commands initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.
1. Print a record of user-defined alarm, supervisory, and trouble events on workstation printer.
2. Sort and report by device name and by function.
3. Report type of signal (alarm, supervisory, or trouble), description, date, and time of occurrence.
4. Differentiate alarm signals from other indications.
5. When system is reset, report reset event with same information concerning device, location, date, and time.

O. Display Monitor:

1. Backlighted LCD to display metered data with touch-screen or touch-pad selecting device.
2. Touch-screen display shall be a minimum 12-inch diagonal, resolution of 800 by 600 RGB pixels, 256 colors; NEMA 250, Type 1 display enclosure.
3. Display four values on one screen at same time.

2.9 COMMUNICATION COMPONENTS AND NETWORKS


B. Network Configuration: High-speed, multi-access, open nonproprietary, industry standard communication protocol; LANs complying with EIA 485, 100 Base-T Ethernet, and Modbus TCP/IP.

2.10 POWER MONITORS

A. Separately mounted, permanently installed instrument for power monitoring and control, complying with UL 1244.

1. Enclosure: NEMA 250, Type 1 or 12.

B. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Indoor installation in non-air-conditioned and nontemperature-controlled spaces that have environmental controls to maintain ambient conditions of 0 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.

C. rms Real-Time Measurements:

1. Current: Each phase, neutral, average of three phases, percent unbalance.
2. Voltage: Line-to-line each phase, line-to-line average of three phases, line-to-neutral each phase, line-to-neutral average of three phases, line-to-neutral percent unbalance.
3. Power: Per phase and three-phase total.
4. Reactive Power: Per phase and three-phase total.
5. Apparent Power: Per phase and three-phase total.
6. Power Factor: Per phase and three-phase total.
7. Displacement Power Factor: Per phase and three-phase total.
8. Frequency.
9. THD: Current and voltage.
10. Accumulated Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).
11. Incremental Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).
12. Conditional Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).

D. Demand Current Calculations, per Phase, Three-Phase Average and Neutral:
   1. Present.
   2. Running average.
   3. Last completed interval.
   4. Peak.

E. Demand Real Power Calculations, Three-Phase Total:
   1. Present.
   2. Running average.
   3. Last completed interval.
   4. Predicted.
   5. Peak.
   6. Coincident with peak kVA demand.
   7. Coincident with kVAR demand.

F. Demand Reactive Power Calculations, Three-Phase Total:
   1. Present.
   2. Running average.
   3. Last completed interval.
   4. Predicted.
   5. Peak.
   6. Coincident with peak kVA demand.
   7. Coincident with kVAR demand.

G. Demand Apparent Power Calculations, Three-Phase Total:
   1. Present.
   2. Running average.
   3. Last completed interval.
   4. Predicted.
   5. Peak.
   6. Coincident with peak kVA demand.
   7. Coincident with kVAR demand.
H. Average Power Factor Calculations, Demand Coincident, Three-Phase Total:
   1. Last completed interval.
   2. Coincident with kW peak.
   3. Coincident with kVAR peak.
   4. Coincident with kVA peak.

I. Power Analysis Values:
   1. THD, Voltage and Current: Per phase, three phase, and neutral.
   2. Displacement Power Factor: Per phase, three phase.
   3. Fundamental Voltage, Magnitude and Angle: Per phase.
   5. Fundamental Real Power: Per phase, three phase.
   8. Phase rotation.
   10. Harmonic Magnitudes and Angles for Current and Voltages: Per phase, up to 31st or 63rd harmonic.

J. Power Demand Calculations: According to one of the following calculation methods, selectable by the user:
   1. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.
   2. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:
      a. Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.
      b. Fixed block that calculates demand at end of the interval.
      c. Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.
   3. Demand Calculation Initiated by a Synchronization Signal:
      a. Signal is a pulse from an external source. Demand period begins with every pulse. Calculation shall be configurable as either a block or rolling block calculation.
      b. Signal is a communication signal. Calculation shall be configurable as either a block or rolling block calculation.
      c. Demand can be synchronized with clock in the power meter.

K. Sampling:
   1. Current and voltage shall be digitally sampled at a rate high enough to provide accuracy to 63rd harmonic of 60-Hz fundamental.
2. Power monitor shall provide continuous sampling at a rate of 128 samples per cycle on all voltage and current channels in the meter.

L. Minimum and Maximum Values: Record monthly minimum and maximum values, including date and time of record. For three-phase measurements, identify phase of recorded value. Record the following parameters:

1. Line-to-line voltage.
2. Line-to-neutral voltage.
3. Current per phase.
4. Line-to-line voltage unbalance.
5. Line-to-neutral voltage unbalance.
6. Power factor.
7. Displacement power factor.
8. Total power.
9. Total reactive power.
10. Total apparent power.
11. THD voltage L-L.
12. THD voltage L-N.
13. THD current.

M. Harmonic Calculation: Display and record the following:

1. Harmonic magnitudes and angles for each phase voltage and current through 31st or 63rd harmonic. Calculate for all three phases, current and voltage, and residual current. Current and voltage information for all phases shall be obtained simultaneously from same cycle.
2. Harmonic magnitude reported as a percentage of the fundamental or as a percentage of rms values, as selected by user.

N. Current and Voltage Ratings:

1. Designed for use with current inputs from standard instrument current transformers with 5 A secondary and shall have a metering range of 0-10 A.
2. Withstand ratings shall not be less than 15 A, continuous; 50 A, lasting over 10 seconds, no more frequently than once per hour; 500 A, lasting 1 second, no more frequently than once per hour.
3. Designed for use with voltage inputs from standard instrument potential transformers with a 120 V-ac secondary.

O. Accuracy:

1. Comply with ANSI C12.20, Class 0.5; and IEC 60687, Class 0.5 for revenue meters. Accuracy from Light to Full Rating shall meet the following criteria:
   a. Power: Accurate to 0.25 percent of reading, plus 0.025 percent of full scale.
b. Voltage and Current: Accurate to 0.075 percent of reading, plus 0.025 percent of full scale.
c. Power Factor: Plus or minus 0.002, from 0.5 leading to 0.5 lagging.
d. Frequency: Plus or minus 0.01 Hz at 45 to 67 Hz.

2. For meters that are circuit-breaker accessories, metering accuracy at full-scale shall not be less than the following:
   a. Current: Plus or minus 2.5 percent.
   b. Voltage: Plus or minus 1.5 percent.
   c. Energy, Demand, and Power: Plus or minus 4.0 percent.
   d. Frequency: Plus or minus 1 Hz.

P. Waveform Capture:
   1. Capture and store steady-state waveforms of voltage and current channels; initiated manually. Each capture shall be for 3 cycles, 128 data points for each cycle, allowing resolution of harmonics to 31st harmonic of basic 60 Hz.
   2. Store captured waveforms in internal nonvolatile memory; available for PC display, archiving, and analysis.

Q. Input: One digital input signal(s).
   1. Normal mode for on/off signal.
   2. Demand interval synchronization pulse, accepting a demand synchronization pulse from a utility demand meter.
   3. Conditional energy signal to control conditional energy accumulation.

R. Outputs:
   1. Operated either by user command sent via communication link, or set to operate in response to user-defined alarm or event.
   2. Closed in either a momentary or latched mode as defined by user.
   3. Each output relay used in a momentary contact mode shall have an independent timer that can be set by user.
   4. One digital KY pulse to a user-definable increment of energy measurement. Output ratings shall be up to 120 V-ac, 300 V-dc, 50 mA, and provide 3500 V-rms isolation.
   5. One relay output module(s), providing a load voltage range from 20 to 240 V-ac or from 20 to 30 V-dc, supporting a load current of 2 A.
   6. Output Relay Control:
      a. Relay outputs shall operate either by user command sent via communication link or in response to user-defined alarm or event.
      b. Normally open and normally closed contacts, field configured to operate as follows:
         1) Normal contact closure where contacts change state for as long as signal exists.
2) Latched mode when contacts change state on receipt of a pickup signal; changed state is held until a dropout signal is received.
3) Timed mode when contacts change state on receipt of a pickup signal; changed state is held for a preprogrammed duration.
4) End of power demand interval when relay operates as synchronization pulse for other devices.
5) Energy Pulse Output: Relay pulses quantities used for absolute kWh, absolute kVARh, kVAh, kWh In, kVARh In, kWh Out, and kVARh Out.
6) Output controlled by multiple alarms using Boolean-type logic.

S. Onboard Data Logging:

1. Store logged data, alarms, events, and waveforms in 80 or 800 KB of onboard nonvolatile memory.
2. Stored Data:
   a. Billing Log: User configurable; data shall be recorded every 15 minutes, identified by month, day, and 15-minute interval. Accumulate 24 months of monthly data, 32 days of daily data, and between 2 and 52 days of 15-minute interval data, depending on number of quantities selected.
   b. Custom Data Logs: One or Three user-defined log(s) holding up to 96 parameters. Date and time stamp each entry to the second and include the following user definitions:
      1) Schedule interval.
      2) Event definition.
      3) Configured as "fill-and-hold" or "circular, first-in first-out."
   c. Alarm Log: Include time, date, event information, and coincident information for each defined alarm or event.
   d. Waveform Log: Store captured waveforms configured as "fill-and-hold" or "circular, first-in first-out."
3. Default values for all logs shall be initially set at factory, with logging to begin on device power up.

T. Alarms:

1. User Options:
   a. Define pickup, dropout, and delay.
   b. Assign one of four severity levels to make it easier for user to respond to the most important events first.
   c. Allow for combining up to four alarms using Boolean-type logic statements for outputting a single alarm.
2. Alarm Events:
a. Over/undercurrent.
b. Over/undervoltage.
c. Current imbalance.
d. Phase loss, current.
e. Phase loss, voltage.
f. Voltage imbalance.
g. Over kW demand.
h. Phase reversal.
i. Digital input off/on.
j. End of incremental energy interval.
k. End of demand interval.

U. Control Power: 90 to 457 V-ac or 100 to 300 V-dc.

V. Communications:

1. Power monitor shall be permanently connected to communicate via Modbus TCP via a 100 Base-T Ethernet or RS-485 Modbus TCP/IP.
2. Local plug-in connections shall be for RS-232 and 100 Base-T Ethernet.

W. Display Monitor:

1. Backlighted LCD to display metered data with touch-screen or touch-pad selecting device.
2. Touch-screen display shall be a minimum 12-inch diagonal, resolution of 800 by 600 RGB pixels, 256 colors; NEMA 250, Type 1 display enclosure.
3. Display four values on one screen at same time.
   a. Current, per phase rms, three-phase average and neutral.
   b. Voltage, phase to phase, phase to neutral, and three-phase averages of phase to phase and phase to neutral.
   c. Real power, per phase and three-phase total.
   d. Reactive power, per phase and three-phase total.
   e. Apparent power, per phase and three-phase total.
   f. Power factor, per phase and three-phase total.
   g. Frequency.
   h. Demand current, per phase and three-phase average.
   i. Demand real power, three-phase total.
   j. Demand apparent power, three-phase total.
   k. Accumulated energy (MWh and MVARh).
   l. THD, current and voltage, per phase.

4. Reset: Allow reset of the following parameters at the display:
   a. Peak demand current.
   b. Peak demand power (kW) and peak demand apparent power (kVA).
   c. Energy (MWh) and reactive energy (MVARh).
2.11 STANDALONE, WEB-ENABLED MONITORING AND CONTROL INSTRUMENT

A. Separately mounted, permanently installed instrument for power monitoring and control.
   1. Enclosure: NEMA 250, Type 1 or 12.

B. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability.
   1. Indoor installation in non-air-conditioned or non-temperature-controlled spaces that have environmental controls to maintain ambient conditions of 0 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.

C. Power-Distribution Equipment Monitor: Web enabled, with integral network port and embedded Web server with factory-configured firmware and HTML-formatted Web pages for viewing of power monitoring and equipment status information from connected devices equipped with digital communication ports.

D. LAN Connectivity: Multipoint, RS-485 Modbus serial communication network, interconnecting all breaker trip units, protective relays, drives, and metering devices equipped with communications. Serial communication network connected to Ethernet server that functions as a gateway and server, providing data access via 10 Base-T LAN.

E. Communication Devices within the Equipment: Addressed at factory and tested to verify reliable communication with network server.

F. Server Configuration:
   1. Initial network parameters set using a standard Web browser. Connect via a local operator interface, or an RJ-45 port accessible from front of equipment.
   2. Network server shall be factory programmed with embedded HTML-formatted Web pages that are user configurable and that provide detailed communication diagnostic information for serial and Ethernet ports as status of RS-485 network; with internal memory management information pages for viewing using a standard Web browser.
   3. Login: Password protected; password administration accessible from the LAN using a standard Web browser.
   4. Operating Software: Suitable for local access; firewall protected.

G. Data Access:
   1. Network server shall include embedded HTML pages providing real-time information from devices connected to RS-485 network ports via a standard Web browser.
H. Equipment Monitoring Options: Login shall be followed by a main menu for selecting summary Web pages that follow.

I. Summary Web pages shall be factory configured to display the following information for each communicating device within the power equipment lineup:

1. User-Configured Custom Home Page: Provide for the lineup, showing status-at-a-glance of key operating values.
2. Circuit Summary Page: Circuit name, three-phase average rms current, power (kW), power factor, and breaker status.
3. Load Current Summary Page: Circuit name, Phase A, B, and C rms current values.
4. Demand Current Summary Page: Circuit name, Phase A, B, and C average demand current values.
5. Power Summary Page: Circuit name, present demand power (kW), peak demand power (kW), and recorded time and date.
6. Energy Summary Page: Circuit name, energy (kWh), reactive energy (kVARh), and time/date of last reset.
7. Transformer Status Page: Transformer tag, coil temperatures, and cooling fan status.
8. Motor-Control Center Status Page: Circuit name, three-phase average rms current, thermal capacity (percentage), and drive output frequency (Hz) contactor status.
9. Specific Device Pages: Each individual communicating device shall display detailed, real-time information, as appropriate for device type.
   a. Display historical energy data that shall be logged automatically for each device, as appropriate for device type.
   b. Display historical data logged from each device in graphical time-trend plots. Value to be displayed on time-trend plot shall be user selectable. Time interval to be displayed on scale shall be for previous day or week.
10. Export historical energy data to a PC or workstation through network using FTP (File Transfer Protocol). Format exported data in a CSV (Comma Separated Variable) file format for importing into spreadsheet applications.

J. Communications:

1. Power monitor: Permanently connected to communicate via RS-485 Modbus TCP/IP or Modbus TCP via a 100 Base-T Ethernet.
2. Local Plug-in Connections: RS-232 and 100 Base-T Ethernet.
3. Monitor Display: Backlighted LCD to display metered data with touch-screen or touch-pad selecting device.
4. The flow computers, power system monitor and Analog/Modbus module shall communicate via RS-485/Modbus RTU. A protocol translator gateway (FieldServer Bridge) connected via RS-485, will provide Ethernet/IP, BACnet IP, and LON or BACnet access points to panel and Modbus network. All building commodities panels will be monitored by the “ION Energy Server” over Ethernet/IP network.
2.12 WORKSTATION HARDWARE

A. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Indoor installation in spaces that have environmental controls to maintain ambient conditions of 36 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.

B. Computer: Standard unmodified PC of modular design, designed for the latest version of Windows operating system.

1. Memory: 256 MB of usable installed memory, expandable to a minimum of 1024 MB without additional chassis or power supplies.
2. Real-Time Clock:
   a. Accuracy: Plus or minus 1 minute per month.
   b. Time Keeping Format: 24-hour time format including seconds, minutes, hours, date, day, and month; automatic reset by software.
   c. Clock shall function for one year without power
   d. Provide automatic time correction once every 24 hours by synchronizing clock with the Time Service Department of the U.S. Naval Observatory.

3. Serial Ports: Two RS-232-F serial ports for general use; one parallel port; four USB ports, with additional ports as required. Data transmission rates shall be selectable under program controlled.
4. Parallel Port: Enhanced.
5. Replaceable graphics board.
6. LAN Adapter Card: 10/100 –Mbps PCI bus, internal network interface card.
7. Sound Card: For playback and recording of digital WAV sound files associated with audible warning and alarm functions.
8. Color Monitor: WXGA TFT, not less than 18 inches, LCD type, with a minimum resolution of 1280 by 1024 pixels, noninterlaced, and a maximum dot pitch of 0.28 mm.
10. Mouse: Standard, compatible with installed software.
11. Minimum Disk Storage: Include the following, each with appropriate controller:
   a. Minimum 80 –GB hard disk, maximum average access time of 10 ms.
   b. Floppy Disk Drive: High density, 3-1/2 inch size.
   c. PCMCIA slot with removable 500 –MB media.
   d. 100 –MB Iomega Zip drive.
   e. 250 –MB Iomega Jaz drive.
12. Magnetic Tape System: 4-mm cartridge magnetic tape system with minimum 12 or 20-GB formatted capacity per tape. Provide 10 tapes, each in a rigid cartridge with spring-loaded cover and operator-selectable write-protect feature.


15. CD-RW/DVD-ROM Drive:
   a. Nominal Storage Capacity: 650 MB.
   b. Data Transfer Rate: 1.2 Mbps.
   c. Average Access Time: 150 ms.
   d. Cache Memory: 256 KB.
   e. Data Throughput: 1 MB/second, minimum.

   a. Connected to central station and designated workstations.
   b. RAM: 2 MB, minimum.
   c. Printing Speed: Minimum 12 pages per minute.

C. Redundant Central Computer: Connected in a hot standby, peer configuration; automatically maintains copies of system software, application software, and data files. System transactions and other activities that alter system data files shall be updated to system files of redundant computer in near real-time. If central computer fails, redundant computer shall assume control immediately and automatically.

D. UPS: Self-contained; complying with requirements as specified.

1. Size: Provide a minimum of 6 hours of operation of workstation station equipment, including 2 hours of alarm printer operation.
3. Accessories:
   a. Transient voltage suppression.
   b. Input-harmonics reduction.
   c. Rectifier/charger.
   d. Battery disconnect device.
   e. Static bypass transfer switch.
   f. Internal maintenance bypass/isolation switch.
   g. External maintenance bypass/isolation switch.
   h. Output isolation transformer.
   i. Remote UPS monitoring.
   j. Battery monitoring.
   k. Remote battery monitoring.
2.13 RS-232 ASCII INTERFACE

A. ASCII interface shall allow RS-232 connections to be made between a meter or circuit monitor operating as the host PC and any equipment that will accept RS-232 ASCII command strings, such as local display panels, dial-up modems and alarm transmitters.

B. Pager System Interface: Alarms shall be able to activate a pager system with customized message for each input alarm.

1. RS-232 output shall be capable of connection to a pager interface that can be used to call a paging system or service and send a signal to a portable pager. System shall allow an individual alphanumeric message per alarm input to be sent to paging system. This interface shall support both numeric and alphanumeric pagers.

C. Alarm System Interface:

1. RS-232 output shall be capable of transmitting alarms from other monitoring and alarm systems to workstation software.

D. Cables:

1. PVC-Jacketed, RS-232 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; PVC jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.

   a. NFPA 70, Type CM.
   b. Flame Resistance: UL 1581, Vertical Tray.

2. Plenum-Type, RS-232 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; plastic jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.

   a. NFPA 70, Type CMP.

2.14 LAN CABLES

A. Comply with contract documents.

B. RS-485 Cable:

1. PVC-Jacketed, RS-485 Cable: Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, PVC insulation, unshielded, PVC jacket, and NFPA 70, Type CMG.
2. Plenum-Type, RS-485 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and fluorinated-ethylene-propylene jacket, and NFPA 70, Type CMP.

C. Unshielded Twisted Pair Cables: Category 5e as specified for horizontal cable for data service in contract documents.

2.15 LOW-VOLTAGE WIRING

A. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Low-Voltage Control Cable: Multiple conductor, color-coded, No. 20 AWG copper, minimum.

1. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.
2. Ordinary Switching Circuits: Three conductors unless otherwise indicated.
3. Switching Circuits with Pilot Lights or Locator Feature: Five conductors unless otherwise indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.

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

3.2 CABLING

A. Comply with NECA 1.

B. Install cables and wiring according to requirements indicated.

C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.

D. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in...
gypsum board partitions where unenclosed wiring method may be used. Use NRTL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.

E. Install LAN cables using techniques, practices, and methods that are consistent with specified category rating of components and that ensure specified category performance of completed and linked signal paths, end to end.

F. Install cables without damaging conductors, shield, or jacket.

3.3 IDENTIFICATION
A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."

B. Label each power monitoring and control module with a unique designation.

3.4 GROUNDING
A. Comply with IEEE 1100, "Recommended Practice for Powering and Grounding Electronic Equipment."

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. Tests and Inspections:

1. Electrical Tests: Use caution when testing devices containing solid-state components.

2. Continuity tests of circuits.

3. Operational Tests: Set and operate controls at workstation and at monitored and controlled devices to demonstrate their functions and capabilities. Use a methodical sequence that cues and reproduces actual operating functions as recommended by manufacturer. Submit sequences for approval. Note response to each test command and
operation. Note time intervals between initiation of alarm conditions and registration of alarms at central-processing workstation.

a. Coordinate testing required by this Section with that required by Sections specifying equipment being monitored and controlled.
b. Test LANs according to requirements in contract documents.
c. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of calculated battery operating time.
d. Verify accuracy of graphic screens and icons.
e. Metering Test: Load feeders, measure loads on feeder conductor with an rms reading clamp-on ammeter, and simultaneously read indicated current on the same phase at central-processing workstation. Record and compare values measured at the two locations. Resolve discrepancies greater than 5 percent and record resolution method and results.
f. Record metered values, control settings, operations, cues, time intervals, and functional observations and submit test reports printed by workstation printer.

E. Power monitoring and control equipment will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.

H. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

I. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

J. Remove and replace malfunctioning devices and circuits and retest as specified above.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems.

1. Train Owner's management and maintenance personnel in interpreting and using monitoring displays and in configuring and using software and reports. Include troubleshooting, servicing, adjusting, and maintaining equipment. Provide a minimum of 12 hours' training.

2. Training Aid: Use approved final versions of software and maintenance manuals as training aids.
3.7 ON-SITE ASSISTANCE

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other-than-normal occupancy hours for this purpose.

END OF SECTION 260913
SECTION 262200 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following types of dry-type transformers rated 600 V-ac and less, with capacities up to 1000 kVA:

1. Distribution transformers.
2. Buck-boost transformers.

1.3 SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.

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.


C. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in Section 260548 "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.

D. Qualification Data: For testing agency.
E. Source quality-control test reports.
F. Field quality-control test reports.
G. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. 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.

B. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

C. 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.

D. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

1.5 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.6 COORDINATION

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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 manufacturers specified.
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or comparable product by one of the following.

2.2 MANUFACTURED UNITS

A. Available Manufacturers:

1. ACME Electric Corporation; Power Distribution Products Division.
2. Challenger Electrical Equipment Corp.; a division of Eaton Corp.
3. Controlled Power Company.
4. Eaton Electrical Sector; Eaton Corporation; Cutler-Hammer Products.
5. Federal Pacific Transformer Company; Division of Electro-Mechanical Corp.
9. Micron Industries Corp.
10. Myers Power Products, Inc.
13. Square D; Schneider Electric.
14. Or Approved Substitute.

2.3 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.
1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Copper.

2.4 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: Totally enclosed, nonventilated, NEMA 250, Type 2.
   1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

E. Enclosure: Totally enclosed, nonventilated, NEMA 250, Type 3R.
   1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

F. Transformer Enclosure Finish: Comply with NEMA 250.
   1. Finish Color: ANSI 49 gray or ANSI 61 gray.

G. Taps for Transformers Smaller Than 3 kVA: One 5 percent tap above normal full capacity.

H. Taps for Transformers 7.5 to 24 kVA: Two 5 percent taps below rated voltage.

I. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

J. Insulation Class: 220 deg F, UL-component-recognized insulation system with a maximum of 302 deg F rise above 104 deg F ambient temperature.

K. Energy Efficiency for Transformers Rated 15 kVA and Larger:
   1. Complying with NEMA TP 1, Class 1 efficiency levels.
   2. Tested according to NEMA TP 2.

L. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
   1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
   2. Indicate value of K-factor on transformer nameplate.
M. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
2. Include special terminal for grounding the shield.
3. Shield Effectiveness:
   a. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.
   b. Common-Mode Noise Attenuation: Minimum of minus 120 dBA at 0.5 to 1.5 kHz; minimum of minus 65 dBA at 1.5 to 100 kHz.
   c. Normal-Mode Noise Attenuation: Minimum of minus 52 dBA at 1.5 to 10 kHz.

N. Wall Brackets: Manufacturer's standard brackets.

O. Fungus Proofing: Permanent fungicidal treatment for coil and core.

P. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

Q. Low-Sound-Level Requirements: Maximum sound levels, when factory tested according to IEEE C57.12.91, as follows:

1. 9 kVA and Less: 40 dB.
2. 30 to 50 kVA: 45 dB.
3. 51 to 150 kVA: 50 dB.
4. 151 to 300 kVA: 55 dB.
5. 301 to 500 kVA: 55 dB.
6. 501 to 750 kVA: 60 dB.
7. 751 to 1000 kVA: 65 dB.

2.5 BUCK-BOOST TRANSFORMERS

A. Description: Self-cooled, two-winding dry type, rated for continuous duty and with wiring terminals suitable for connection as autotransformer. Transformers shall comply with NEMA ST 1 and shall be listed and labeled as complying with UL 506 or UL 1561.

B. Enclosure: Ventilated, NEMA 250, Type 2.

1. Finish Color: ANSI 49 gray or ANSI 61 gray.

2.6 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates
2.7 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.91.

B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

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

3.2 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

1. Brace wall-mounting transformers as specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

B. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Section 260529 "Hangers and Supports for Electrical Systems." Transformers shall be mounted on Type E neoprene isolators with 0.15 inch static deflection.

and label products are specified in Section 260553 "Identification for Electrical Systems."
3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections 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 each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

D. Remove and replace units that do not pass tests or inspections and retest as specified above.

E. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.
   1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
   2. Perform 2 follow-up infrared scans of transformers, one at 4 months and the other at 11 months after Substantial Completion.
   3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

F. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.


3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262200
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes metal-enclosed, low-voltage power circuit-breaker switchgear rated 1000 V-ac and less for use in ac systems.

B. Related Sections include the following:

1. All contract documents.

1.3 DEFINITIONS


B. GFCI: Ground-fault circuit interrupter.

1.4 SUBMITTALS

A. Product Data: For each type of switchgear, circuit breaker, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each type of switchgear and related equipment.

1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:

a. Tabulation of installed devices with features and ratings.
b. Enclosure types and details.
c. Outline and general arrangement drawing showing dimensions, shipping sections, and weights of each assembled section.
d. Bus configuration with size and number of conductors in each bus run, including phase, neutral, and ground conductors of main and branch buses.
e. Current rating of buses.
f. Short-time and short-circuit current rating of switchgear assembly.
g. Nameplate legends.
h. Mimic-bus diagram.

i. Utility company's metering provisions with indication of approval by utility company.

j. NRTL listing for series rating of installed devices.

k. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear where pipe and ducts are prohibited. Show switchgear layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Samples: Representative portion of mimic bus with specified finish. Manufacturer's color charts showing colors available for mimic bus.

E. Manufacturer Seismic Qualification Certification: Submit certification that switchgear, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Section 260548 "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis of 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.

F. Qualification Data: For testing agency.

G. Field quality-control test reports.

H. Updated mimic-bus diagram reflecting field changes after final switchgear load connections have been made, for record.

I. Operation and Maintenance Data: For switchgear and components to include in emergency, operation, and maintenance manuals. 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.
1.5 QUALITY ASSURANCE

A. 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.

B. Source Limitations: Obtain switchgear through one source from a single manufacturer.

C. Product Options: Drawings indicate size, profiles, and dimensional requirements of switchgear and are based on the specific system indicated. Retain first paragraph below if labeling of switchgear is required. See Editing Instruction No. 2 in the Evaluations.

D. 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.

E. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchgear in sections of lengths that can be moved past obstructions in delivery path.

B. Store switchgear indoors in clean dry space with uniform temperature to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. If stored in areas subjected to weather, cover switchgear to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchgear; install electric heating (250 W per section) to prevent condensation.

1.7 PROJECT CONDITIONS

A. Installation Pathway: Remove and replace building components and structures to provide pathway for moving switchgear into place.

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 Engineer, Construction Manager and Owner no fewer than two days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Engineer’s, Construction Manager’s and Owner's written permission.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchgear, including clearances between switchgear, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:

1. Ambient Temperature: Not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

1.8 COORDINATION

A. Coordinate layout and installation of switchgear and components with other construction that penetrates ceilings or is supported by them, including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels.

B. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Six of each type and rating used. Include spares for potential transformer fuses, control power fuses, and fuses and fusible devices for fused circuit breakers.
2. Indicating Lights: Six of each type installed.
3. Touchup Paint: 3 containers of paint matching enclosure finish, each 0.5 pint.
2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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 manufacturers specified.
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or comparable product by one of the following.

2.2 MANUFACTURED UNITS

A. Available Manufacturers:

1. ABB Inc.
5. Square D; Schneider Electric.
6. Or Approved Substitute.

2.3 RATINGS

A. Nominal System Voltage: 480/277 V-ac, 4 and 208/120 V-ac, 4 wire, 60 Hz.
B. Main-Bus Continuous: 1200 A.
C. Short-Time and Short-Circuit Current: Match rating of highest-rated circuit breaker in switchgear assembly.

2.4 FABRICATION

A. Factory assembled and tested and complying with IEEE C37.20.1.
B. Indoor Enclosure Material: Steel.
C. Outdoor Enclosure Material: Galvanized steel.
D. Outdoor Enclosure Fabrication Requirements: Weatherproof; integral structural-steel base frame with factory-applied asphaltic undercoating; and each compartment equipped with the following features:
1. Structural design and anchorage adequate to resist loads imposed by 125-mph wind.
2. Space heater operating at one-half or less of rated voltage, sized to prevent condensation.
3. Louvers equipped with insect and rodent screen and filter; arranged to permit air circulation while excluding insects, rodents, and exterior dust.
4. Hinged front door with padlocking provisions.
5. Interior light with switch.
7. Common internal aisle of sufficient width to permit protective-device withdrawal, disassembly, and servicing in aisle.
8. Aisle access doors with outside padlocking provisions and interior panic latches.
9. Aisle space heaters operating at one-half or less of rated voltage, thermostatically controlled.
10. Vaporproof fluorescent aisle lights with low-temperature ballasts, controlled by wall switch at each entrance.
11. GFCI duplex receptacles, a minimum of two, located in aisle.
12. Aisle ventilation louvers equipped with insect and rodent screen and filter and arranged to permit air circulation while excluding insects, rodents, and exterior dust.

E. Finish: IEEE C37.20.1, manufacturer's standard gray finish over a rust-inhibiting primer on phosphatizing-treated metal surfaces.

F. Section barriers between main and tie circuit-breaker compartments shall be extended to rear of section.

G. Bus isolation barriers shall be arranged to isolate line bus from load bus at each main and tie circuit breaker.

H. Circuit-breaker compartments shall be equipped to house drawout-type circuit breakers and shall be fitted with hinged outer doors.

I. Fabricate enclosure with removable, hinged, rear cover panels to allow access to rear interior of switchgear.

J. Auxiliary Compartments: Match and align with basic switchgear assembly. Include the following:
   1. Utility metering compartment that complies with utility company requirements.
   2. Bus transition sections.
   3. Incoming-line pull sections.
   4. Hinged front panels for access to metering, accessory, and blank compartments.
   5. Pull box on top of switchgear for extra room for pulling cable, with removable top, front, and side covers and ventilation provisions adequate to maintain air temperature in pull box within same limits as switchgear.
a. Set pull box back from front to clear circuit-breaker lifting mechanism.
b. Bottom: Insulating, fire-resistant material with separate holes for cable drops into switchgear.
c. Cable Supports: Arranged to ease cabling and adequate to support cables indicated, including those for future installation.

K. Bus bars connect between vertical sections and between compartments. Cable connections are not permitted.

1. Main Phase Bus: Uniform capacity the entire length of assembly.
3. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.
5. Use copper for connecting circuit-breaker line to copper bus.
6. Contact Surfaces of Buses: Silver plated.
7. Feeder Circuit-Breaker Load Terminals: Silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.
8. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size 1/4-by-2 inches.
10. Neutral bus equipped with pressure-connector terminations for outgoing circuit neutral conductors. Neutral-bus extensions for busway feeders are braced.
11. Neutral Disconnect Link: Bolted, uninsulated, 1/4-by-2-inch copper bus, arranged to connect neutral bus to ground bus.
12. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.
13. Bus-Bar Insulation: Individual bus bars wrapped with factory-applied, flame-retardant tape or spray-applied, flame-retardant insulation.

a. Sprayed Insulation Thickness: 3 mils, minimum.
b. Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.

2.5 COMPONENTS


1. Potential Transformers: Secondary-voltage rating of 120 V-ac and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
2. **Current Transformers**: Ratios as indicated; burden and accuracy class suitable for connected relays, meters, and instruments.

B. **Multifunction Digital-Metering Monitor**: UL-listed or -recognized, microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Inputs from sensors or 5 A current-transformer secondaries, and potential terminals rated to 600 V-ac.

2. Switch-selectable digital display of the following:
   
   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. **Three-Phase Real Power**: Plus or minus 2 percent.
   e. **Three-Phase Reactive Power**: Plus or minus 2 percent.
   f. **Power Factor**: Plus or minus 2 percent.
   g. **Frequency**: Plus or minus 0.5 percent.
   h. **Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes**: Plus or minus 2 percent.
   i. **Accumulated energy, in megawatt hours (joules)**, plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

3. **Mounting**: Display and control unit flush or semiflush mounted in instrument compartment door.

4. **Watt-Hour Meters**: Flush- or semiflush-mounting type, 5 A, 120 V-ac, 3 phase, 3 wire; with 3 elements, 15-minute indicating demand register, and provision for testing and adding pulse initiation.

5. **Recording Demand Meter**: Usable as totalizing relay or indicating and recording maximum demand meter with 15-minute interval.
   
   a. **Operation**: Meter counts and records a succession of pulses entering two channels.
   b. **Housing**: Drawout, black-connected case arranged for semiflush mounting.

C. **Analog Instruments**: Rectangular, 4-1/2-inch square, accurate within 1 percent, semiflush mounting, with antiparallax 250-degree scale and external zero adjustment, complying with ANSI C39.1.

1. **Voltmeters**: Cover an expanded scale range of normal voltage plus 10 percent.

2. **Voltmeter Selector Switch**: Rotary type with off position to provide readings of phase-to-phase and phase-to-neutral voltages.

3. **Ammeters**: Cover an expanded scale range of bus rating plus 10 percent.

4. **Ammeter Selector Switch**: Permits current reading in each phase and keeps current-transformer secondary circuits closed in off position.

5. Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.
6. Watt-Hour Meters: Flush- or semiflush-mounting type, 5 A, 120 V-ac, 3 phase, 3 wire; with 3 elements, 15-minute indicating demand register, and provision for testing and adding pulse initiation.

7. Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with 15-minute interval.
   a. Operation: Meter counts and records a succession of pulses entering two channels.
   b. Housing: Drawout, back-connected case arranged for semiflush mounting.

D. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.

   1. Install in cable termination compartments and connect in each phase of circuit.
   2. Coordinate rating with circuit voltage.

F. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.

G. Fungus Proofing: Permanent fungicidal treatment for switchgear interior, including instruments and instrument transformers.

H. Control Power Supply: Control power transformer supplying 120 V-ac control circuits through secondary disconnect devices. Include the following features:
   1. Dry-type transformers, in separate compartments for units larger than 3 kVA, including primary and secondary fuses.
   2. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.
      a. Secondary windings connected through a relay or relays to control bus to effect an automatic transfer scheme.
      b. Secondary windings connected through an internal automatic transfer switch to switchgear control power bus.
   4. Fuses are specified in Section 262813 "Fuses."

I. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:
   1. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
   2. Conductors sized according to NFPA 70 for duty required.
2.6 CIRCUIT BREAKERS

A. Description: Comply with IEEE C37.13.

B. Ratings: As indicated for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.

C. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:

1. Normal Closing Speed: Independent of both control and operator.
2. Slow Closing Speed: Optional with operator for inspection and adjustment.
4. Operation counter.

D. Trip Devices: Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:

1. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
2. Temperature Compensation: Ensures accuracy and calibration stability from 23 to 104 deg F.
3. Field-adjustable, time-current characteristics.
4. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.
5. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
7. Pickup Points: Five minimum, for instantaneous-trip functions.
8. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide protection for the following:

   a. Three-wire circuit or system.
   b. Four-wire circuit or system.
   c. Four-wire, double-ended substation.

9. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.

E. Auxiliary Contacts: For interlocking or remote indication of circuit-breaker position, with spare auxiliary switches and other auxiliary switches required for normal circuit-breaker operation, quantity as indicated. Each consists of two Type "a" and two Type "b" stages (contacts) wired through secondary disconnect devices to a terminal block in stationary housing.
F. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, and disconnected positions. Include the following features:

1. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed, and prevent closure of circuit breaker unless it is in connected, test, or disconnected position.
2. Circuit-Breaker Positioning: An open circuit breaker may be racked to or from connected, test, and disconnected positions only with the associated compartment door closed unless live parts are covered by a full dead-front shield. An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open. Status for connection devices for different positions includes the following:
   a. Test Position: Primary disconnect devices disengaged, and secondary disconnect devices and ground contact engaged.
   b. Disconnected Position: Primary and secondary devices and ground contact disengaged.

G. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position, and arranged to permit inspection of contacts without removing circuit breaker from switchgear.

H. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.

I. Operating Handle: One for each circuit breaker capable of manual operation.

J. Electric Close Button: One for each electrically operated circuit breaker.

K. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.

L. Key Interlocks: Arranged so keys are attached at devices indicated. Mountings and hardware are included where future installation of key-interlock devices is indicated.

M. Undervoltage Trip Devices: Adjustable time-delay and pickup voltage.

N. Shunt-Trip Devices: Where indicated.

O. Fused Circuit Breakers: Circuit breaker and fuse combinations complying with requirements for circuit breakers and trip devices and with the following:

1. Fuses: NEMA FU 1, Class L current limiting, sized to coordinate with and protect associated circuit breaker.
2. Circuit Breakers with Frame Size 1600 A and Smaller: Fuses on line side of associated circuit breaker, on a common drawout mounting, arranged so fuses are accessible only when circuit breaker is in disconnected position.
3. Circuit Breakers with Frame Sizes More Than 1600 A: Fuses and circuit breakers may be installed in separate compartments on separate drawout mountings. Fuse drawout element is interlocked with associated power circuit breaker to prevent drawing out fuse element unless circuit breaker is in open position.

4. Open-Fuse Trip Device: Positive means of tripping and holding circuit breaker in open position when a fuse opens. Open-fuse status is indicated at front of circuit breaker or fuse drawout element.

P. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.

2.7 ACCESSORIES

A. Accessory Set: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.

1. Racking handle to manually move circuit breaker between connected and disconnected positions.
2. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.
3. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.


C. Circuit-Breaker Removal Apparatus: Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of drawout circuit breaker installed.

D. Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.

E. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

2.8 IDENTIFICATION

A. Mimic Bus: Continuous mimic bus, arranged in single-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.

1. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual presentation of principal switchgear components and connections.
2. Medium: Painted graphics, as selected by Engineer.
3. Color: Contrasting with factory-finish background; as selected by Engineer from manufacturer's full range.

B. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads. Include as-built data for low-voltage power switchgear and connections as follows:

1. Frame size of each circuit breaker.
2. Trip rating for each circuit breaker.
3. Conduit and wire size for each feeder.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces where switchgear will be installed for compliance with installation tolerances, required clearances, and other conditions affecting performance.

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

3.2 INSTALLATION

A. Comply with applicable portions of NECA 400.

B. Anchor switchgear assembly to 4-inch, channel-iron floor sill embedded in floor or concrete base and attach by bolting.

1. Sills: Select to suit switchgear; level and grout flush into floor or concrete base.
2. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Section 260548 "Vibration and Seismic Controls for Electrical Systems" for seismic-restraint requirements.
3. Concrete Bases: 4 inches high, reinforced, with chamfered edges. Extend base no more than 3 inches in all directions beyond the maximum dimensions of switchgear unless otherwise indicated or unless required for seismic anchor support. Construct concrete bases according to Section 260529 "Hangers and Supports for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from switchgear units and components.
3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Section 260553 "Identification for Electrical Systems."

B. Diagram and Instructions:

1. Frame and mount under clear acrylic plastic on the front of switchgear.
   a. Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.
   b. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.

2. Storage for Maintenance: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

3.4 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:

1. Inspect switchgear installation, including wiring, components, connections, and equipment. Test and adjust components and equipment.
2. 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 electrical Sections.
3. Complete installation and startup checks according to manufacturer's written instructions.
4. Assist in field testing of equipment including pretesting and adjusting of equipment and components.
5. Report results in writing.

C. Testing Agency: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.

D. Perform the following field tests and inspections and prepare test reports:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for each of the following NETA categories:
   a. Switchgear.
   b. Circuit breakers.
   c. Protective relays.
   d. Instrument transformers.
   e. Metering and instrumentation.
   f. Ground-fault systems.
   g. Battery systems.
   h. Surge arresters.
   i. Capacitors.

2. Remove and replace malfunctioning units and retest as specified above.

E. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.

   1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 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 switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Set field-adjustable, protective-relay trip characteristics according to results in plans.

B. Set field-adjustable, protective-relay trip characteristics.

3.7 CLEANING

A. On completion of installation, inspect interior and exterior of switchgear. Remove paint splatters and other spots. Vacuum dirt and debris; do not use
compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.8 PROTECTION

A. Temporary Heating: Apply temporary heat to switchgear, according to manufacturer's written instructions, throughout periods when switchgear environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchgear.

END OF SECTION 262300
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

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 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter

C. RFI: Radio-frequency interference.

D. RMS: Root mean square.

E. SPDT: Single pole, double throw.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards 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 and the unit will be fully operational after the seismic event."
1.5 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.
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 graph 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.

D. Manufacturer Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Section 260548 "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.

E. Qualification Data: For qualified testing agency.

F. Field quality-control test reports including the following:
   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.

G. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. 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.
   4. Quantity installed for each size and type, but no fewer than one of each size and type.

1.6 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: 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 Agency (NETA) or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

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 “Deadfront Distribution Switchboards.”

G. Comply with NFPA 70.

H. Comply with UL 891.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Store indoors in clean dry space with uniform temperature to prevent condensation. Protect from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. If stored in areas subjected to weather, cover switchboards to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchboards; install temporary electric heating (250 W per section) to prevent condensation.

D. Handle and prepare switchboards for installation according to NECA 400 and NEMA PB 2.1.

1.8 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 Engineer, Construction Manager and Owner 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 Engineer's, Construction Manager's and Owner's written permission.
4. Comply with NFPA 70E.

1.9 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 in Division 3.

1.10 EXTRA MATERIALS

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.

1.11 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 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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 manufacturers specified.
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or comparable product by one of the following.

2.2 MANUFACTURED UNITS

A. Available Manufacturers:

4. Square D; a brand of Schneider Electric.
5. Or Approved Substitute.

B. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Panel-mounted or fixed, individually mounted.
3. Sections front and rear aligned.

C. Front- and Side-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
3. Sections front and rear aligned.

D. Front- and Rear-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel and fixed, individually or fixed and individually compartment mounted.
3. Sections front and rear aligned.

E. Nominal System Voltage: 480Y/277 V-ac or 208Y/120 V-ac.
F. Main-Bus Continuous: 1200 A.

G. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

H. Indoor Enclosures: Steel, NEMA 250, Type 1.

I. Enclosure Finish for Outdoor Units: Factory-applied finish in manufacturer's standard color, undersurfaces treated with corrosion-resistant undercoating.

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 or downward, rearward sloping roof; rear hinged doors 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 104 deg F.
   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 complete with replaceable fiberglass air filters.
   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 120/208 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. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.


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 captive thumb screws or 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.

a. If bus is copper, use copper for feeder circuit-breaker line connections.

2. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with pressure connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.

3. Ground Bus: 1/4-by-2-inch- minimum-size required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with pressure 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.

4. Contact Surfaces of Buses: Silver plated

5. 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: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

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 221 deg F.

X. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

2.3 TRANSIENT VOLTAGE SUPPRESSION DEVICES

A. Available Manufacturers:

4. Square D; a brand of Schneider Electric.
5. Or Approved Substitute.

B. Surge Protection Device Description: IEEE C62.41-compliant, integrally mounted, plug-in style, 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.
C. Minimum single-impulse current rating shall be as follows:

1. Line to Neutral: 100,000 A.
2. Line to Ground: 100,000 A.
3. Neutral to Ground: 50,000 A.

D. Protection modes shall be as follows:

1. Line to neutral.
2. Line to ground.
3. Neutral to ground.

E. EMI/RFI Noise Attenuation Using 50-ohm Insertion Loss Test: 55 dB at 100 kHz.

F. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase or 120 kA per mode/240 kA per phase.

G. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 and 208Y/120 V-ac, three-phase, four-wire circuits shall be as follows:

1. Line to Neutral: 800 V-ac for 480Y/277 and 400 V-ac for 208Y/120.
2. Line to Ground: 800 V-ac for 480Y/277 and 400 V-ac for 208Y/120.
3. Neutral to Ground: 800 V-ac for 480Y/277 and 400 V-ac for 208Y/120.

H. Protection modes and UL 1449 SVR for 240, 480, or 600 V-ac, three-phase, three-wire, delta circuits shall be as follows:

2. Line to Ground: 1500 V-ac for 480 V-ac.

I. Withstand Capabilities: 3000 Category C surges with less than 5 percent change in clamping voltage.

J. 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. 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.
9. Audible alarm, with silencing switch, to indicate when protection has failed.
10. Six-digit, transient-event counter set to totalize transient surges.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489 and NEMA AB 3, with interrupting capacity to meet available fault currents.


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).


B. Molded-Case Circuit-Breaker (MCCB) Features and Accessories: Not all accessories and options listed in subparagraphs below are available for every rating and from every listed manufacturer. Verify availability and unique characteristics with manufacturers selected. Standard frame sizes, trip ratings, and number of poles:

1. See Editing Instruction No. 5 in the Evaluations for guidance on using mechanical vs. compression lugs.

2. Lugs: Compression style, 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 (HID) lighting circuits.

4. Select first option in first subparagraph below for solid-state trip units; select second option for thermal-magnetic trip units. If selecting second option, also retain "Shunt Trip" Subparagraph below.
5. **Ground-Fault Protection:** Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

6. **Zone-Selective Interlocking:** Integral with electronic trip unit; for interlocking ground-fault protection function.

7. **Communication Capability:** Circuit-breaker-mounted or Universal-mounted communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."

8. **Shunt Trip:** 120 V-ac trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.

9. **Undervoltage Trip:** Set to operate at 35 to 75 percent of rated voltage without intentional or with field-adjustable 0.1- to 0.6-second time delay.

10. **Auxiliary Contacts:** One SPDT switch or two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

11. **Key Interlock Kit:** Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

12. **Zone-Selective Interlocking:** Integral with electronic trip unit; for interlocking ground-fault protection function.

C. **Enclosed, 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. Standard-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 pickup levels.
   c. Long- and short-time adjustments with $I^2t$ response.
   d. Ground-fault pickup level, time delay, and $I^2t$ response.

4. Remote trip indication and control.

5. **Communication Capability:** Integral communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."

6. **Key Interlock Kit:** Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

7. **Zone-Selective Interlocking:** Integral with electronic trip unit; for interlocking ground-fault protection function.

8. **Control Voltage:** 125 or 250 V-ac.

9. **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).

10. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

D. 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. Available Manufacturers:
   c. Siemens Energy & Automation, Inc.
   d. Square D; a brand of Schneider Electric.
   e. Or Approved Substitute

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).
SWITCHBOARDS

7. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

E. High-Pressure, Butt-Type Contact Switch: Operating mechanism uses butt-type contacts and a spring-charged mechanism to produce and maintain high-pressure contact when switch is closed.

1. Available Manufacturers:
   c. Siemens Energy & Automation, Inc.
   d. Square D; a brand of Schneider Electric.
   e. Or Approved Substitute.

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: Integ rally 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.

F. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

G. Fuses are specified in Section 262813 "Fuses."
2.5 INSTRUMENTATION

A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:

1. Potential Transformers: Secondary voltage rating of 120 V-ac and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Ratios shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments.
3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.

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. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.
   i. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
   j. Contact devices to operate remote impulse-totalizing demand meter.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.


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:
   2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V-ac, 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. 15-minute-indicating-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.
   13. Provision for testing and adding pulse initiation.

G. Impulse-Totalizing Demand Meter:
   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 15 minute maximum demand of totalized system.

2.6 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-ac 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.

2.7 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.


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.

2.8 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. 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.
D. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.

E. 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 Protection:

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer’s written instructions.

3.2 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NECA 400 and 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.

3.3 INSTALLATION

A. Install switchboards and accessories according to NECA 400 and NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified as specified.

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 260548 "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.

3.4 CONNECTIONS

A. Comply with requirements for terminating feeder bus as specified. Drawings indicate general arrangement of bus, fittings, and specialties.

B. Comply with requirements for terminating cable trays as specified. Drawings indicate general arrangement of cable trays, fittings, and specialties.

3.5 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with an engraved metal or laminated-plastic nameplate complying with requirements for identification specified in Section 260553 "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 260553 "Identification for Electrical Systems."
3.6 FIELD QUALITY CONTROL

A. Prepare for age a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. 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.

C. Prepare for acceptance tests as follows:
   1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

D. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

E. Perform the following field tests and inspections and prepare test reports:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Sections 7.1, 7.5, 7.6, 7.9, 7.10, 7.11, and 7.14 as appropriate. 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.
         2) Prepare 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.
   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.

3.7 CLEANING

A. On completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.8 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.

3.9 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.

END OF SECTION 262413
SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 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.
5. Transient voltage suppression panelboards.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.
B. GFCI: Ground-fault circuit interrupter.
C. RFI: Radio-frequency interference.
D. RMS: Root mean square.
E. SPDT: Single pole, double throw.
F. SVR: Suppressed voltage rating.
G. TVSS: Transient voltage surge suppressor.

1.4 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.


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 graph paper; include selectable ranges for each type of overcurrent protective device.

C. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Section 260548 "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.

D. Qualification Data: For qualified testing agency.

E. 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.

F. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

G. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. 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.

1.5 QUALITY ASSURANCE

A. 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 (NETA) or the National Institute for Certification in Engineering Technologies 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, Article 100, by a qualified testing agency, and marked for intended location and application.

E. Comply with NEMA PB 1.

F. Comply with NFPA 70.

1.6 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 NECA 407 and NEMA PB 1.

1.7 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 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 Engineer, Construction Manager and Owner no fewer than two days in advance of proposed interruption of electric service.
   2. Do not proceed with interruption of electric service without Engineer’s, Construction Manager’s and Owner’s written permission.
   3. Comply with NFPA 70E.

1.8 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.

1.9 EXTRA MATERIAL

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: Six spares for each type of panelboard cabinet lock.
   2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Six 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.

1.10 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 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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 manufacturers specified.
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or comparable product by one of the following.

2.2 MANUFACTURED UNITS

A. Available Manufacturers:

1. Panelboards, Overcurrent Protective Devices, Controllers, Contractors, and Accessories:
   c. Siemens Energy & Automation, Inc.
   d. Square D; a brand of Schneider Electric.
   e. Or Approved Substitute.

2. Transient Voltage Suppression Panelboards:
   b. Liebert Corporation.
   c. Or Approved Substitute.
B. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

C. Enclosures: Flush- and surface-mounted cabinets. NEMA PB 1, Type 1.
   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. Kitchen 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.
      f. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.
   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: Same finish as panels and trim.
      c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

D. Incoming Mains Location: Top and bottom.

E. Phase, Neutral, and Ground Buses:
   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.
F. Conductor Connectors: Suitable for use with conductor material and sizes.

2. Main and Neutral Lugs: Compression type.
3. Ground Lugs and Bus-Configured Terminators: Compression type.
4. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
5. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
6. Gutter-Tap Lugs: Compression 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.

G. 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.

H. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

I. 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.


2.3 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 and the unit will be fully operational after the seismic event."

B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 1.

2.4 DISTRIBUTION PANELBOARDS

A. Panelboards: NEMA PB 1, power and feeder distribution type.

B. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
1. For doors more than 36 inches high, provide two latches, keyed alike.

C. Mains: Circuit breaker.


E. 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.

F. Branch Overcurrent Protective Devices: Fused switches.

G. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically 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-ac branch circuit.

2.5 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

B. Mains: Circuit breaker.

C. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

D. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically 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-ac branch circuit.

E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

F. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.6 LOAD CENTERS

A. Load Centers: Comply with UL 67.

B. Mains: Circuit breaker.
C. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.

D. Conductor Connectors: Mechanical type for main, neutral, and ground lugs and buses.

2.7 ELECTRONIC-GRADE PANELBOARDS

A. Available Manufacturers:

1. Current Technology; a subsidiary of Danahar Corporation.
2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
4. Liebert Corporation.
5. Siemens Energy & Automation, Inc.
6. Square D; a brand of Schneider Electric.
7. Or Approved Substitute.

B. Panelboards: NEMA PB 1; with factory-installed, integral TVSS; labeled by an NRTL for compliance with UL 67 after installing TVSS.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

D. Main Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.

E. Branch Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.

F. Buses:

1. Copper phase and neutral buses; 200 percent capacity neutral bus and lugs.
2. Copper equipment and isolated ground buses.

2.8 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

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 sensitivity).


9. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

   a. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
   b. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
   c. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   d. Communication Capability: Circuit-breaker-mounted or Universal-mounted or Integral communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
   e. Shunt Trip: 120 V-ac trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
   f. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional or with field-adjustable 0.1- to 0.6-second time delay.
   g. Auxiliary Contacts: One SPDT switch or two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
   h. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
   i. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
   j. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
   k. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
I. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on position.
   m. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

B. 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 262813 "Fuses."
   2. Fused Switch Features and Accessories: Standard ampere ratings and number of poles.
   3. Auxiliary Contacts: One or Two normally open and normally closed contact(s) that operate with switch handle operation.

2.9 CONTROLLERS

A. Motor Controllers: NEMA ICS 2, Class A, combination controller equipped for panelboard mounting and including the following accessories:
   1. Individual control-power transformers.
   2. Fuses for control-power transformers.
   4. Indicating lights.
   5. Seal-in contact.
   6. 3 convertible auxiliary contacts.
   7. Push buttons.
   8. Selector switches.

B. Contactors: NEMA ICS 2, Class A, combination controller equipped for panelboard mounting and including the following accessories:
   1. Individual control-power transformers.
   2. Fuses for control-power transformers.
   3. Indicating lights.
   4. Seal-in contact.
   5. 3 convertible auxiliary contacts.
   7. Selector switches.

C. Controller Disconnect Switches: Fused switch or Adjustable instantaneous-trip circuit breaker, integrally mounted and interlocked with controller.
   1. Auxiliary Contacts: Integral with disconnect switches to de-energize external control-power source.

D. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held general-purpose controller.
1. Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.

2. Control-Power Source: 120 V-ac branch circuit.

2.10 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.

C. Fungus Proofing: Permanent fungicidal treatment for panelboard interior, including over-current protective devices and other components.

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 as specified.

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 260548 "Vibration and Seismic Controls for Electrical Systems."

E. Mount top of trim 74 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 260553 "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 an engraved metal or laminated-plastic nameplate complying with requirements for identification specified in Section 260553 "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 260553 "Identification for Electrical Systems."

3.4 CONNECTIONS

A. Ground equipment according to Section 260526 “Grounding and Bonding for Electrical Systems.”

B. Connect wiring according to Section 260519 “Low-Voltage Electrical Power Conductors and Cables.”

3.5 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. 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.

C. Prepare for acceptance tests as follows:
   1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

D. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

E. Perform the following field tests and inspections and prepare test reports:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. 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.

F. 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.

G. Infrared Scanning:

1. 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.
2. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
3. Instruments and Equipment:
   a. Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
4. Record of Infrared Scanning: Prepare a certified report that identifies panelboards checked and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

H. Panelboards will be considered defective if they do not pass tests and inspections.

I. 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.

3.6 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 indicated.
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.

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer’s written instructions.

3.8 CLEANING

A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 262416
SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 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.
5. Isolated-ground receptacles.
6. Tamper-resistant receptacles.
7. Weather-resistant receptacles.
8. Snap switches and wall-box dimmers.
10. Wall-switch and exterior occupancy sensors.
11. Communications outlets.
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 SUBMITTALS
   A. Product Data: For each type of product indicated.
   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.
   D. Field quality-control test reports.
   E. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE

1.6 COORDINATION:
   A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
      1. Cord and Plug Sets: Match equipment requirements.

1.7 EXTRA MATERIALS
   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; a division of Cooper Industries, Inc. (Cooper).
      2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).
5. Or Approved Substitute.

B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

C. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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 manufacturers specified.
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or comparable product by one of the following.
4. Available products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
5. Products: Subject to compliance with requirements, provide one of the following:

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-ac, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. Available products:
   a. Cooper; 5351 (single), CR5352 (duplex).
   b. Hubbell; HBL5351 (single), HBL5352 (duplex).
c. Leviton; 5891 (single), 5352 (duplex).
d. Pass & Seymour; 5381 (single), 5352 (duplex).
e. Or Approved Substitute.

B. Isolated-Ground, Duplex Convenience Receptacles, 125 V-ac, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. Available products:
   a. Cooper; IG5362RN.
   b. Hubbell; CR 5253-IG.
   c. Leviton; 5362-IG.
   d. Pass & Seymour; IG6300.
   e. Or Approved Substitute.

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.

C. Tamper-Resistant Convenience Receptacles, 125 V-ac, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498 Supplement sd, and FS W-C-596.

1. Available products:
   a. Cooper; TR8300.
   b. Hubbell; HBL8300SGA.
   c. Leviton; 8300-SGG.
   d. Pass & Seymour; 63H.
   e. Or Approved Substitute.

2.4 GFCI RECEPTACLES

A. General Description:

1. Straight blade, feed or non-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 is lighted when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles, 125 V-ac, 20 A:

1. Available products:
   a. Cooper; GF20.
   b. Hubbell; GFR5352L.
   c. Pass & Seymour; 2084.
   d. Leviton; 7590.
C. Tamper-Resistant GFCI Convenience Receptacles, 125 V-ac, 20 A:

1. Available products:
   a. Hubbell; GFTR20.
   b. Pass & Seymour; 2095TR.
   c. Or Approved Substitute.

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-ac 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. Available products:
   a. Cooper; 5362BLS.
   b. Hubbell; HBL5362SA.
   c. Leviton; 5380.
   d. Pass & Seymour; 5362BLSP.
   e. Or Approved Substitute.

2. Description: Straight blade, 125 V-ac, 20 A; NEMA WD 6 Configuration 5-20R.

C. Isolated-Ground, Duplex Convenience Receptacles:

1. Available products:
   a. Cooper; IG5362BLS.
   b. Hubbell; IG5362SA.
   c. Leviton; 5380-IG.
   d. Pass & Seymour; IG5362BLSP.
   e. Or Approved Substitute.

2. Description:
   a. Straight blade, 125 V-ac, 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.

2.6 HAZARDOUS (CLASSIFIED) LOCATION RECEPTACLES

A. Available Wiring Devices for Hazardous (Classified) Locations: Comply with NEMA FB 11 and UL 1010.

1. Available Manufacturers:
   a. Cooper Crouse-Hinds.
   b. EGS/Appleton Electric.
   c. Killark; a division of Hubbell Inc.
   d. Or Approved Substitute.

2.7 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V-ac, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.

1. Available products:
   a. Cooper; L520R.
   b. Hubbell; HBL2310.
   c. Leviton; 2310.
   d. Pass & Seymour; L520-R.
   e. Or Approved Substitute.

B. Isolated-Ground, Single Convenience Receptacles, 125 V-ac, 20 A:

1. Available products:
   a. Cooper; IGL520R.
   b. Hubbell; IG2310.
   c. Leviton; 2310-IG.
   d. Pass & Seymour; IG4700.
   e. Or Approved Substitute.

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.
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: Match voltage and current ratings and number of conductors to requirements of equipment being connected.

1. 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.

2.10 SNAP SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120/277 V-ac, 20 A:

1. Available products:

   1) Single Pole:
      a) Cooper; 2221.
      b) Hubbell; CS1221.
      c) Leviton; 1221-2.
      d) Pass & Seymour; 20AC1.
      e) Or Approved Substitute.

   2) Two Pole:
      a) Cooper; 2222.
      b) Hubbell; CS1222.
      c) Leviton; 1222-2.
      d) Pass & Seymour; 20AC2.
      e) Or Approved Substitute.

   3) Three Way:
a) Cooper; 2223.
b) Hubbell; CS1223.
c) Leviton; 1223-2.
d) Pass & Seymour; 20AC3.
e) Or Approved Substitute.

4) Four Way:
   a) Cooper; 2224.
   b) Hubbell; VS1224.
   c) Leviton; 1224-2.
   d) Pass & Seymour; 20AC4.
   e) Or Approved Substitute.

C. Pilot-Light Switches, 20 A:

1. Available products:
   a. Cooper; 1221PL for 120 and 277 V-ac.
   b. Hubbell; HBL1221PL for 120 and 277 V-ac.
   c. Leviton; 1221-PLR for 120 V, 1221-7PLR for 277 V-ac.
   d. Pass & Seymour; PS20AC1-PLR for 120 V, PS20AC1-PLR7 for 277 V-ac.
   e. Or Approved Substitute.

2. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."

D. Key-Operated Switches, 120/277 V-ac, 20 A:

1. Available products:
   a. Cooper; 2221L.
   b. Hubbell; HBL1221L.
   c. Leviton; 1221-2L.
   d. Pass & Seymour; PS20AC1-L.
   e. Or Approved Substitute.

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-ac, 20 A; for use with mechanically held lighting contactors.

1. Available products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2. Products: Subject to compliance with requirements, provide one of the following:
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F. Key-Operated, Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches: 120/277 V-ac, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.

1. Available products:
   a. Cooper; 1995L.
   b. Hubbell; HBL1557L.
   c. Leviton; 1257L.
   d. Pass & Seymour; 1251L.
   e. Or Approved Substitute.

2.11 DECORATOR-STYLE DEVICES

A. Convenience Receptacles: Square face, 125 V-ac, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, and UL 498.

1. Available products:
   a. Cooper; 6252.
   b. Hubbell; DR15.
   c. Leviton; 16252.
   d. Pass & Seymour; 26252.
   e. Or Approved Substitute.

B. Tamper-Resistant Convenience Receptacles: Square face, 125 V-ac, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, and UL 498.

1. Available products:
   a. Cooper; TR6252.
   b. Hubbell; DR15TR.
   c. Pass & Seymour; TR26252.
   d. Or Approved Substitute.

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-ac, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, and UL 498.

1. Available products:
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WIRING DEVICES

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1. Available products:

a. Cooper; TWRBR15.
b. Hubbell; DR15TR.
c. LevitonTRW15.
d. Pass & Seymour; TRW26252.
e. Or Approved Substitute.

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 or Non-Feed-Through Type, Convenience Receptacles: Square face, 125 V-ac, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, UL 498, and UL 943 Class A.

1. Available products:

a. Cooper; VGF15.
b. Hubbell; GF15LA.
c. Leviton; 8599.
d. Pass & Seymour; 1594.
e. Or Approved Substitute.

E. GFCI, Tamper-Resistant and Weather-Resistant Convenience Receptacles: Square face, 125 V-ac, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, UL 498, and UL 943 Class A.

1. Available products:

a. Cooper; TWRVGF15.
b. Hubbell; GFTR15.
c. Pass & Seymour; 1594TRWR.
d. Or Approved Substitute.

G. Lighted Toggle Switches, Square Face, 120 V, 15 A: Comply with NEMA WD 1 and UL 20.
1. Available products:
   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).
   e. Or Approved Substitute.

2. Description: With neon-lighted handle, illuminated when switch is "ON."

2.12 RESIDENTIAL DEVICES

A. Residential-Grade, Tamper-Resistant Convenience Receptacles, 125 V-ac, 15 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, and UL 498.

1. Available products:
   a. Cooper; TR270.
   b. Hubbell; RR155TR.
   c. Leviton; T5320.
   d. Pass & Seymour; TR62.
   e. Or Approved Substitute.

2. Description: Labeled to comply with NFPA 70, "Receptacles, Cord Connectors, and Attachment Plugs (Caps)" Article, "Tamper-Resistant Receptacles in Dwelling Units" Section.

B. Weather-Resistant and Tamper-Resistant Convenience Receptacles, 125 V-ac, 15 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, and UL 498.

1. Available products:
   a. Cooper; TWR270.
   b. Hubbell; RR155WRTR.
   c. Leviton; TWR15.
   d. Pass & Seymour; 3232TRWR.
   e. Or Approved Substitute.

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.

2.13 WALL-BOX DIMMERS

A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
B. Control: Continuously adjustable slider or toggle switch or rotary knob; with single-pole or three-way switching. Comply with UL 1472.

C. Incandescent Lamp Dimmers: 120 V-ac; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.
   1. 600 W; dimmers shall require no derating when ganged with other devices. Illuminated when "OFF."

D. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.14 FAN SPEED CONTROLS

A. Modular, 120-V-ac, full-wave, solid-state units with integral, quiet on-off switches and audible frequency and EMI/RFI filters. Comply with UL 1917.
   1. Continuously adjustable slider or toggle switch or rotary knob, 5 A.
   2. Three-speed adjustable slider or rotary knob, 1.5 A.

2.15 OCCUPANCY SENSORS

A. Wall-Switch Sensors:
   1. Available products:
      a. Cooper; 6111 for 120 V-ac, 6117 for 277 V-ac.
      b. Hubbell; WS1277.
      c. Leviton; ODS 10-ID.
      d. Pass & Seymour; WS3000.
      e. Watt Stopper (The); WS-200.
      f. Exergy Controls.
      g. Or Approved Substitute.
   2. Description: Passive-infrared type, 120/277 V-ac, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft.

B. Wall-Switch Sensors:
   1. Available products:
      a. Hubbell; AT120 for 120 V-ac, AT277 for 277 V-ac.
      b. Leviton; ODS 15-ID.
      c. Exergy Controls.
      d. Or Approved Substitute.
2. Description: Adaptive-technology type, 120/277 V-ac, adjustable time delay up to 20 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft.

C. Long-Range Wall-Switch Sensors:

1. Available products:
   a. Hubbell; ATP1600WRP.
   b. Leviton; ODWWV-IRW.
   c. Pass & Seymour; WA1001.
   d. Watt Stopper (The); CX-100
   e. Exergy Controls.
   f. Or Approved Substitute.

2. Description: Passive-infrared type, 120/277 V-ac, adjustable time delay up to 30 minutes, 110-degree field of view, with a minimum coverage area of 1200 sq. ft.

D. Long-Range Wall-Switch Sensors:

1. Available products:
   a. Hubbell; ATD1600WRP.
   b. Leviton; ODW12-MRW.
   c. Watt Stopper (The); DT-w00.
   d. Exergy Controls.
   e. Or Approved Substitute.

2. Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V-ac, adjustable tie delay up to 30 minutes, 110-degree field of view, and a minimum coverage area of 1200 sq. ft.

E. Wide-Range Wall-Switch Sensors:

1. Available products:
   a. Hubbell; ATP120HBRP.
   b. Leviton; ODWHB-IRW.
   c. Pass & Seymour; HS1001.
   d. Watt Stopper (The); CX-100-3.
   e. Exergy Controls.
   f. Or Approved Substitute.

2. Description: Passive-infrared type, 120/277 V-ac, adjustable time delay up to 30 minutes, 150-degree field of view, with a minimum coverage area of 1200 sq. ft.

F. Exterior Occupancy Sensors:
1. Available products:
   a. Leitven; PS200-10.
   b. Watt Stopper (The); EW-100-120.
   c. Or Approved Substitute.

2. Description: Passive-infrared type, 120/277 V-ac, weatherproof, adjustable time delay up to 15 minutes, 180-degree field of view, and 110-foot detection range. Minimum switch rating: 1000 W incandescent, 500 VA fluorescent.

2.16 COMMUNICATIONS OUTLETS

A. Telephone Outlet:

1. Available products:
   a. Cooper; 3560-6.
   b. Leitven; 40649.
   c. Or Approved Substitute.

2. Description: Single RJ-45 jack for terminating 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e. Comply with UL 1863.

B. Combination TV and Telephone Outlet:

1. Available products:
   a. Cooper; 3562.
   b. Leitven; 40595.
   c. Or Approved Substitute.

2. Description: Single RJ-45 jack for 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e; and one Type F coaxial cable connector. Comply with UL 1863.

2.17 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
4. Material for Damp Locations: Thermoplastic or Cast aluminum 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 or thermoplastic with lockable cover.

2.18 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type or flap-type or above-floor, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: Rectangular, die-cast aluminum or 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: Two modular, keyed, color-coded, RJ-45 jacks for UTP cable.

2.19 POKE-THROUGH ASSEMBLIES

A. Available Manufacturers:

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Pass & Seymour/Legrand; Wiring Devices & Accessories.
3. Square D; a brand of Schneider Electric.
4. Thomas & Betts Corporation.
5. Wiremold Company (The).
6. Or Approved Substitute.

B. Description: Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service-outlet assembly. Comply with UL 514 scrub water exclusion requirements.

1. Service-Outlet Assembly: Flush type with two simplex receptacles and space for two RJ-45 jacks or flush type with four simplex receptacles and space for four RJ-45 Category 5e jacks
2. Size: Selected to fit nominal 3-inch or 4-inch cored holes in floor and matched to floor thickness.
3. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
4. Closure Plug: Arranged to close unused 3-inch or 4-inch cored openings and reestablish fire rating of floor.
5. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of two or four, four-pair, Category 5e voice and data communication cables.
2.20 PREFABRICATED MULTIOUTLET ASSEMBLIES

A. Available Manufacturers:
   1. Hubbell Incorporated; Wiring Device-Kellems.
   2. Wiremold Company (The).
   3. Or Approved Substitute.

B. 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.

C. Raceway Material:  Metal, with manufacturer's standard finish.

D. Multioutlet Harness:
   1. Receptacles:  15 A, 125 V-ac, NEMA WD 6 Configuration 5-15R receptacles complying with NEMA WD 1, UL 498, and FS W-C-596.
   2. Receptacle Spacing:  12 inches or 18 inches.
   3. Wiring:  No. 12 AWG solid, Type THHN copper, single circuit or two circuit, connecting alternating receptacles.

2.21 SERVICE POLES

A. Description: 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.

1. 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.
2. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.
3. Finishes: Manufacturer's standard painted finish and trim combination or satin-anodized aluminum.
4. 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.
5. Power Receptacles: Two duplex, 20 A, straight-blade receptacles complying with requirements in this Section.
6. Voice and Data Communication Outlets: Blank insert with bushed cable opening or two RJ-45 Category 5e jacks or four RJ-45 Category 5e jacks.

2.22 FINISHES

A. Device Color:
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1. Wiring Devices Connected to Normal Power System: White or as selected by Engineer unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Power System: Yellow painted faceplates or a yellow adhesive dot applied to the faceplate.
3. TVSS Devices: Blue.
4. Isolated-Ground Receptacles: Orange or as specified above, with orange triangle on face.

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. Take steps to 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. Pig tailing 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 up, and on horizontally mounted receptacles to the right.

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 260553 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black or white-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 and prepare test reports:

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V-ac.
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. Wiring device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 262726
SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 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, panelboards, switchboards and enclosed controllers.
2. Plug fuses rated 125 V-ac and less for use in plug-fuse-type enclosed switches and panelboards.
4. Spare-fuse cabinets.

1.3 SUBMITTALS

A. Product Data: Include the following for each type and rating of fuse indicated:

1. Dimensions and manufacturer’s technical data on features, performance, electrical characteristics, and ratings.
2. Let-through current curves (instantaneous peak let-through current) for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt), coordination charts and tables, and related data.
4. Fuse size for elevator feeders and elevator disconnect switches.

B. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

1. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
2. Provide manufacturer’s technical data on which ambient temperature adjustment calculations are based.

C. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. Include the following:
1. Ambient temperature adjustment information.
2. Let-through current curves (instantaneous peak let-through current) for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt), coordination charts and tables, and related data.

1.4 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, Article 100, 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.

1.5 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.

1.6 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Quantity equal to 10 percent of each fuse type and size, but no fewer than 6 of each type and size
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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 manufacturers specified.
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or comparable product by one of the following.

2.2 MANUFACTURED UNITS

A. Available Manufacturers:

1. Cooper Bussmann, Inc.
3. Edison Fuse, Inc.
4. Ferraz Shawmut, Inc.
5. Littelfuse, Inc.
7. Or Approved Substitute.

2.3 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

2.4 PLUG FUSES

A. Characteristics: UL 248-11, nonrenewable plug fuses; 125 V-ac.

2.5 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.
2.6 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted, 0.05-inch thick 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 L, fast acting; J, fast acting or T, fast acting.
2. Feeders: Class RK1, fast acting; RK5, time delay or J, fast acting.
3. Motor Branch Circuits: Class RK1 or RK5, time delay.
4. Other Branch Circuits: Class RK1, time delay; RK5, time delay or J, time delay.
5. Control Circuits: Class CC, fast acting.

B. Plug Fuses:

1. Motor Branch Circuits: Edison-base type, dual; Edison-base type, single; Type S, dual or Type S, single-element time delay.
2. Other Branch Circuits: Edison-base type, single-element fast acting; Edison-base type, dual-element time delay; Edison-base type, single-element time delay; Type S, dual-element time delay or Type S, single-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 260553 "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 262813
SECTION 262816 - 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY
A. This Section includes the following individually mounted, enclosed switches and circuit breakers:

1. Fusible switches.
2. Nonfusible switches.
3. Bolted-pressure contact switches.
4. High-pressure, butt-type contact switches.
5. Receptacle switches.
7. Molded-case circuit breakers (MCCBs).
8. Molded-case switches.

1.3 DEFINITIONS
A. GD: General duty.
B. GFCI: Ground-fault circuit interrupter.
C. HD: Heavy duty.
D. NC: Normally closed.
E. NO: Normally open.
F. RMS: Root mean square.
G. SPDT: Single pole, double throw.

1.4 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.

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.

C. Manufacturer Seismic Qualification Certificates: Submit certification that enclosed switches and circuit breakers, accessories, and components will withstand seismic forces defined in contract document. 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.

D. Qualification Data: For qualified testing agency.

E. 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.

F. Manufacturer's field service report.

G. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. 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.

1.5 QUALITY ASSURANCE

A. 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 (NETA) or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

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. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a qualified testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

D. Comply with NFPA 70.

E. 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.

1.6 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 Engineer, Construction Manager and Owner 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 Engineer’s, Construction Manager’s and Owner’s written permission.
4. Comply with NFPA 70E.

1.7 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.

1.8 EXTRA MATERIAL
A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Spares: For the following:

2. Spare Indicating Lights: Six of each type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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 manufacturers specified.
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or comparable product by one of the following.

2.2 FUSIBLE AND NONFUSIBLE SWITCHES
A. Available Manufacturers:
2. General Electric Company; Electrical Distribution & Control Division.
4. Square D; a brand of Schneider Electric.
5. Or Approved Substitute.

B. Fusible Switch, Type HD, Heavy Duty, Single Throw, 120 or 208 V-ac, 600 or 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.

C. Nonfusible Switch, Type HD, Heavy Duty, Six Pole, Single Throw, 120 or 208 V-ac, 600 or 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. 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 style with compression lug kits suitable for number, size, and conductor material.
   8. Service-Rated Switches: Labeled for use as service equipment.
   9. Accessory Control Power Voltage: Remote mounted and powered; 120 or 208 V-ac.

2.3 FUSED POWER CIRCUIT DEVICES

A. Service-Rated Switches: Labeled for use as service equipment.

B. 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.

   1. Configuration: Integrally mounted or remote-mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground fault indicator.
   2. Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.
3. No-Trip Relay Test: Operation of “no-trip” test control permits ground-fault simulation test without tripping switch.
4. Test Control: Simulates ground fault to test relay and switch (or relay only if “no-trip” mode selected).

C. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

2.4 RECEPTACLE SWITCHES

A. Available Manufacturers

2. General Electric Company; Electrical Distribution & Control Division.
4. Square D; a brand of Schneider Electric.
5. Or Approved Substitute.

B. Type HD, Heavy-Duty, Single-Throw Fusible Switch: 120 or 208 V-ac, 30 or 60 or 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.

C. Type HD, Heavy-Duty, Single-Throw Nonfusible Switch: 120 or 208 V-ac, 30 or 60 or 100 A; UL 98 and NEMA KS 1; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

D. 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.

E. Receptacle: Polarized, three-phase, four-wire receptacle (fourth wire connected to enclosure ground lug).

2.5 SHUNT TRIP SWITCHES

A. Available Manufacturers

1. Cooper Bussmann, Inc.
2. Ferraz Shawmut, Inc.
3. Littelfuse, Inc.
4. Or Approved Substitute.

B. 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.

C. 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.
D. Control Circuit: 120 V-ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power transformer or source of enough capacity to operate shunt trip, connected pilot, and indicating and control devices.

E. Accessories:

1. Oiltight key switch for key-to-test function.
2. Oiltight white or yellow 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.

2.6 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

A. Available Manufacturers:

2. General Electric Company; Electrical Distribution & Control Division.
5. Square D; a brand of Schneider Electric.
6. Or Approved Substitute.

B. Molded-Case Circuit Breaker: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to meet available fault currents.


D. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

E. 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.

F. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.
G. 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.

H. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6 mA trip).

I. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30 mA trip).

J. Molded-Case Circuit Breaker Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical style with compression lug kits suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HCAR for heating, air-conditioning, and refrigerating equipment.
4. Ground-Fault Protection: Comply with UL 1053; Integrally mounted, self-powered or 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.
5. Communication Capability: Circuit-breaker-mounted, universal-mounted, integral or din-rail-mounted communication module with functions and features compatible with power monitoring and control system, specified in Section 260913 "Electrical Power Monitoring and Control."
6. Shunt Trip: 120 V-ac trip coil energized from separate circuit, with coil-clearing contact, set to trip at 55 percent of rated voltage.
7. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional or with field-adjustable 0.1- to 0.6-second time delay.
8. Auxiliary Contacts: One SPDT switch or two SPDT switches 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 or 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 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 or remote mounted and powered; 120 or 208 V-ac.

K. Molded-Case Switches: Molded-case circuit breaker with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

L. Molded-Case Switch Features and Accessories:
1. Standard frame sizes and number of poles.
2. Lugs: Mechanical style with compression lug kits suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Type HACR for heating, air-conditioning, and refrigerating equipment.
4. 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.
5. Shunt Trip: 120 V-ac trip coil energized from separate circuit, with coil-clearing contact, set to trip at 55 percent of rated voltage. Provide "dummy" trip unit where required for proper operation.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional or with field-adjustable 0.1- to 0.6-second time delay.
7. Auxiliary Contacts: One SPDT switch or two SPDT switches with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
8. Alarm Switch: One NO or NC contact that operates only when switch has tripped.
9. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
10. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
11. Electrical Operator: Provide remote control for on, off, and reset operations.
12. Accessory Control Power Voltage: Integrally mounted, self-powered or remote mounted and powered; 120 or 208 V-ac.

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.
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 7C.
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 CONCRETE BASES
A. Coordinate size and location of concrete bases. Verify requirements with Engineer.

B. Concrete base is specified in Section 260548 “Vibration and Seismic Controls for Electrical Systems,” and concrete materials and installation requirements are as specified.

3.3 INSTALLATION
A. Comply with NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated. Anchor floor-mounting switches to concrete base.

C. Comply with mounting and anchoring requirements specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in fusible devices.

3.4 IDENTIFICATION
A. Comply with requirements in Section 260553 "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.
3.5 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, and to assist in field testing. Report results in writing.

B. Prepare for acceptance testing as follows:

1. Inspect mechanical and electrical connections.
2. Verify switch and relay type and labeling verification.
3. Verify rating of installed fuses.
4. Inspect proper installation of type, size, quantity, and arrangement of mounting or anchorage devices complying with manufacturer's certification.

C. 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.

D. Testing Agency: Engage a qualified testing agency to perform the following field tests and inspections and prepare test reports:

E. Tests and Inspections:

1. Test mounting and anchorage devices according to requirements in Section 260548 “Vibration and Seismic Controls for Electrical Systems.”
2. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
4. 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. Open or 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, Equipment and Reports:

      1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2) Prepare a certified report that identifies enclosed switches and circuit breakers included and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

5. 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.

3.6 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.

3.7 CLEANING

A. On completion of installation, vacuum dirt and debris from interiors; do not use compressed air to assist in cleaning.

B. Inspect exposed surfaces and repair damaged finishes.

END OF SECTION 262816
SECTION 263213 - ENGINE GENERATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes packaged engine-generator sets for emergency power supply with the following features:

1. Diesel engine.
2. Unit-mounted cooling system.
3. Unit-mounted and remote-mounting control and monitoring.
4. Performance requirements for sensitive loads.
5. Outdoor enclosure.

B. Provide all labor, materials, and equipment necessary for a complete and operable emergency/standby electric generating system. Materials and equipment shall be new and delivered to the project site completely wired, tested, and ready for installation.

C. Related Sections include the following:

1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

D. Applicable Codes and Standards:

1. The emergency generator system shall comply with the following codes and standards: NFPA Codes and related adoptions (amendments) by the State of California, IEEE Standards, Environment Protection Agency (EPA) Emission Standards, California Air Resource Board (CARB), Hazardous Materials Compliance Division (HMCD), South Coast Air Quality Management District (SCAQMD), and ANSI/NEMA standards.
2. All products shall be listed and labeled for the application by UL or another Nationally Recognized Testing Laboratory (NRTL).
1.3 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.

B. LP: Liquid petroleum.

1.4 SYSTEM REQUIREMENTS

A. Engine-generator set rated as indicated on Drawings. The Work includes supplying and installing a complete integrated generator system. The system consists of a diesel generator set with related component accessories and automatic transfer switches specified under a separate section.

B. Engine-generator control consoles resiliently mounted on generating sets shall include complete engine start/stop controls and monitoring systems.

C. Provide all necessary control devices components, accessories, parts, tests, documents, and services needed to meet the requirements of this Specification; or as otherwise indicated on Drawings.

D. Electric generating system must meet requirements of NFPA 110 including design specifications, prototype tests, one-step full-load pickup, installation and testing.

E. Starting batteries and battery charger.

F. Provide remote start with status connection from the Campus Energy Management System (EMS).


H. Voltage and frequency regulation.

I. Generator set mounted on vibration isolation supports to provide 96% isolation in order to minimize vibration of the remainder of the skid-mounted equipment and transmission of vibration to the supporting pad.

J. Prime and finish paint with manufacturer’s standard paint finish; paint shall be lead free.

K. Outdoor units shall be totally enclosed and rated for outdoor use. The housing shall have hinged side-access doors and rear control door. All doors shall be lockable.

L. Fuel tanks and piping: Underground fuel tanks are not acceptable. Above ground fuel tanks shall have double wall welded steel construction and be sized to provide the generator set system with fuel for a minimum of 24 hours operating at continuous load power output. Above ground tanks may be sub-
base or remote located as appropriate for the application, and shall be provided with a rupture basin.

M. The Contractor shall provide a full tank of diesel fuel for the completion of all testing.

N. Complete monitoring and alarms.

O. The Contractor shall assist and submit in any permitting mandated by the governing agency for the diesel generator set and related component accessories.

P. Generator(s) greater than 50 brake horsepower within 100 feet of student occupied sites shall be equipped with particle exhaust filter in compliance with all legally required monitoring and control equipment as required by regulatory agencies having jurisdictions.

Q. The equipment supplied and installed shall meet the requirements of the NEC and all applicable local codes and regulations. All equipment shall be a new and current production by a manufacturer who has 25 years of experience building this type of equipment. Manufacturer shall be ISO9001 certified.

1.5 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.
5. Include control diagrams, list of materials, catalog cuts, technical data, manufacturer's specifications, and applicable installation details.

C. Manufacturer Seismic Qualification Certification: Submit certification that day tank, engine-generator set, batteries, battery racks, accessories, and
components will withstand seismic forces defined in Section 260548 "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.

D. Qualification Data: For installer, manufacturer and testing agency.

E. Submit 3 copies of service manuals including the following:
   1. A detailed explanation of the operation of the system.
   2. Instructions for routine maintenance.
   3. Detailed instructions for repair of major components of the system.
   4. Pictorial parts list and part numbers.
   5. Pictorial and schematic electrical drawings of wiring systems, including operating and safety devices, control panels, annunciators, and major components.
   6. Installation instructions for system components.
   7. Final test report.
   8. Record drawings of the system exactly as it was installed, including plan and elevation views with overall and interconnection point dimensions, and diagrams including schematic and interconnection diagrams.

F. 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.
   4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
   6. Report of exhaust emissions showing compliance with applicable regulations.

G. Field quality-control test reports.

H. Warranty: Special warranty specified in this Section.
I. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. 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.

J. Submit a detailed typewritten sequence of operations as part of the approval documents. Approved sequence of operations shall be permanently encapsulated in plastic laminate and permanently attached to the equipment. Format shall be 8.5 by 11 inches or 11 by 17 inches as appropriate.

1.6 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. Equipment, including engine-generator sets, shall be from a single manufacturer regularly engaged in the production of engine-generator sets for a minimum of 10 years. Entire system shall be factory built, tested, and shipped so there is one source of supply and responsibility for warranty, parts, and service.

D. 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 (NETA) or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

E. Submit certified performance test for this or an exact duplicate prototype unit for Engineer of Record review. Refer to part three for additional requirements.

F. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
G. 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.

H. Equipment, fuel, and exhaust components shall be sized in accordance with manufacturer’s recommendations and requirements.

I. Comply with ASME B15.1.

J. Comply with NFPA 37.

K. Comply with NFPA 70.

L. Comply with NFPA 99.

M. Comply with NFPA 110 requirements for Level 2 emergency power supply system.

N. Comply with UL 2200.

O. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

P. 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.

1.7 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 Engineer, Construction Manager and Owner no fewer than two days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Engineer’s, Construction Manager’s and Owner’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: 41 to 104 deg F.
2. Relative Humidity: 0 to 95 percent.
3. Altitude: Sea level to 1000 feet.

C. Unusual Service Conditions: Engine-generator equipment and installation are required to operate under the following conditions:
1. High salt-dust content in the air due to sea-spray evaporation.

1.8 COORDINATION

A. Coordinate size and location of concrete bases for package engine generators and remote radiators mounted on grade. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in contract documents.

B. Coordinate size and location of roof curbs, equipment supports, and roof penetrations for remote radiators.

1.9 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: Complete standby electric power system including all accessories shall be warranted by the manufacturer for a period of five years from date or 1,500 operating hours, whichever occurs first, of Substantial Completion.

2. Multiple warranties for individual components are not permitted. Satisfactory warranty documents must be provided.

1.10 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. Provide a supply of oil, fuel, coolant, and air filter elements required for one complete engine generator system tune-up.

1.11 EXTRA MATERIAL

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.

PART 2 - PRODUCTS

2.1 ENGINE

A. Approved manufacturers are Cummins, Generac, Detroit Diesel-Allison, or Campus Approved Substitute. Approved engine-generator set shall be Cummins Power Generation QSB7 Series Engine Model DSGAA or Campus Approved Substitute.

B. General: System shall include engine-generator sets rated for the KW, and KVA, at 0.8 PF, 3-phase, 4-wire, and volts on a continuous standby basis, as indicated on Drawings.

C. Engine-generator sets shall be installed on heavy-duty steel bases to maintain proper alignment between components. Sets shall incorporate vibration isolators of type and quantity specified by set manufacturer, whether mounted internally or externally to set.

D. Diesel engines shall meet the following requirements:

1. Engine shall be stationary, liquid-cooled, diesel for use with number 2 diesel fuel. Design shall be 4-cycle, 6 cylinders, turbocharged and intercooled where required by engine manufacturer as capable of developing rated BHP at 1800 rpm, and driving a generator yielding a KW rating as specified herein. Engine shall be capable of driving generator of this rating on a continuous standby basis for duration of normal utility source interruptions per SAE J1349 conditions. Fuel injection and valves shall not require adjustments while in service.

2. Engine equipment shall include following:

   a. An electric starter, as required.
   b. Positive displacement, mechanical full pressure lubrication oil pump, full flow lubrication oil filters with replaceable elements and dipstick oil level indicator.
   c. Fuel filter with replaceable element, and an engine driven, mechanical positive displacement fuel pump, mounted on engine. Replaceable dry element air clearer.
   d. Engine speed isochronous electronic governing system to control generator frequency within plus or minus 0.25 of rated frequency under steady state load conditions, and capable of parallel operation with load sharing controls.
   e. Engine protection devices shall be furnished with sensing elements located on engine to initiate following preliminary alarms and engine shutdowns:
1) Low coolant temperature alarm.
2) Pre-warning for low lubrication oil pressure alarm.
3) Pre-warning for high coolant temperature alarm.
4) Low lubrication oil pressure shutdown.
5) High coolant temperature shutdown.
6) Overspeed shutdown.
7) Overcrank lockout.
8) Low fuel.

f. Provide low coolant level shutdown, which shall activate high engine temperature lamp and shutdown.
g. Engine starter battery charging alternator with solid-state voltage regulator.
h. Provide engine mounted thermostatically controlled water jacket heater and necessary circuit from normal utility power source to aid engine's quick start.

E. Engine Cooling Systems:

1. Engine shall be radiator cooled by engine mounted radiator system including belt-driven blower fan, coolant pump, and thermostat temperature control. Performance of components shall be as required by set manufacturer. For indoor units, radiators shall be provided with a duct adapter flange permitting attachment of air discharge duct directing discharge of radiator air through the wall. Provide ducts and flexible duct connection between duct adapter flange and wall louver or damper.

2. Provide 50 percent ethylene glycol antifreeze solution to fill engine cooling system. Provide gaskets and packing in the cooling system which are unaffected by the ethylene glycol base coolant.

3. For generators installed indoors, provide automatic motorized dampers for inlet air and radiator discharge air located and sized as indicated on Drawings. Dampers for inlet air shall provide adequate air volume for engine combustion, ventilation, and radiator cooling air. Dampers shall operate automatically to close when engine stops and to open when engine starts, power for dampers shall be taken from an emergency panel.

4. Provide coolant temperature safety device.

F. Engine Lubricating System:

1. Provide full pressure type with engine driven positive displacement sump pump, full flow strainer and flow filter, pressure relief and automatic bypass valves.

2. Provide indicating pressure gauges on the upstream and downstream side of the strainer and filter, and water shutoff valves and drain on the oil cooler to facilitate drainage of water without draining the complete engine cooling system.

3. Low oil pressure safety shutoff device.

4. Drain connection.

5. Crankcase ventilator with filter and connection for outside venting.
G. Engine Exhaust Systems:

1. Exhaust mufflers shall be provided for each engine of size as recommended by manufacturer. Mufflers shall be of residential type and shall be installed so its weight is not supported by engine.
2. Flexible exhaust connections shall be provided as required for connection between engine exhaust manifolds and exhaust line, in compliance with applicable codes and regulations.
3. Provide an exhaust condensation trap with manual drain valve to trap and drain off exhaust condensation and to prevent condensation from entering engine.
4. Provide a suitable rain cap at stack outlet. Provide necessary flanges and special fittings for proper installation.
5. Mount and install exhaust components as indicated on Drawings and as required to comply with applicable codes and regulations. Components shall be proper sized to assure proper operation without excessive backpressure when installed as indicated on Drawings. Provide provisions as required for pipe expansion and contraction.
6. Cover indoor installed exhaust mufflers, and piping with proper insulating material in a manner not to interfere with flexible exhaust connections.
7. Where outdoor housings are provided, exhaust mufflers shall be mounted inside housing.
8. Provide silencer.

H. Engine Fuel Systems:

1. Provide fuel system piping sizing as indicated on Drawings or as required for proper fuel flow of diesel fuel to engine. Provide supply return, vent, and fill lines as indicated on Drawings, along with fittings. Provide connections for connecting fuel system to engines in compliance with applicable codes and regulations.
2. Provide 24-hour sub-base tank, gauges, valves, tank filler fittings, tank vent fittings, day tank float and necessary items as indicated on Drawings to comply with applicable codes and regulations. Fuel sub-base tank and fuel accessories shall be new. Sub-base tank shall be of double-walled construction and located underneath skid base of engine generator set.
3. A low fuel supply sensing device shall be installed on fuel tank. Sensing device shall be adjusted to signal low fuel level when tank contains less than a 3-hour supply. The 3-hour supply level shall be as recommended by manufacturer of engine-generator set.
4. A fuel-in-rupture basin alarm shall be provided with contacts available for annunciation.
5. Fuel tank shall be filled to capacity with low sulfur diesel fuel; fuel shall comply with the Air Quality Management District requirements. Provide necessary documentation at time of delivery.


J. Rated Engine Speed: 1800 rpm.

K. Maximum Piston Speed for Four-Cycle Engines: 1464 fpm.
L. 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.

M. Engine Fuel System:

2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

N. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.

O. Governor: Adjustable isochronous, with speed sensing.

P. 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 gauge 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.
   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.

Q. Cooling System: Closed loop, liquid cooled, with remote radiator and integral engine-driven coolant pump.

1. Configuration: Horizontal air discharge.
2. Radiator Core Tubes: Aluminum or 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 gauge glass and petcock.

5. Fan: Driven by multiple belts from engine shaft or 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.

R. Muffler/Silencer: Residential type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 18 dB at 500 Hz.

2. Sound level measured at a distance of 10 feet from exhaust discharge after installation is complete shall be 75 dBA or less.

S. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

T. Starting System: 12 V-ac 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 twice or 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 50 deg F regardless of external ambient temperature within range specified in Part 1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.


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 \textit{minus 40 deg to plus 140 deg F} 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.


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.

2.2 GENERATORS

A. Generators shall be single-bearing, self-aligning, 4-pole, synchronous type, revolving field with amortisseur windings, with direct drive centrifugal blower for proper cooling and minimum noise with temperature compensated solid-state voltage regulator, with brushless rotating rectifier exciter system. Brushes will not be allowed. Generator shall be directly connected to engine flywheel housing and driven through a flexible coupling to insure permanent alignment; gear driven generators are not permitted under this Specification. Insulation shall meet NEMA standards for Class F, in addition to the quality assurance requirements indicated above. Maximum temperature rise shall not exceed 266 deg F. Generator design shall prevent potentially damaging shaft currents.

B. Three-phase, broad range, reconnectible generator shall be furnished with 12 leads brought out to allow connection by user to obtain any of available voltages for unit.

C. Voltage regulator shall be solid-state design and shall function by controlling exciter magnetic field between stator and rotor to provide no load to full load regulation of rated voltage within plus or minus 2 percent during steady-state conditions. Engine-generator set and regulator must sustain at least 90 percent of no-load voltage for 10 seconds with 250 percent of rated load at near zero power factor connected to its terminals.

D. Voltage regulator shall be insensitive to severe load induced waveshape distortion from SCR or thyristor circuits such as those used in battery charging (UPS) and motor speed control equipment.
E. A rheostat shall provide a minimum of plus or minus 5 percent voltage adjustment from rated value.

F. Generator, exciter and voltage regulator shall be designed and manufactured by engine-generator set manufacturer so that characteristics shall be matched to torque curve of prime mover. This design allows prime mover to use its fullest power producing capacity (without exceeding it or over compensating) at speeds lower than rated to provide fastest possible system recover from transient speed dips. A system that routinely selects a linear-type (straight line) constant volts/hertz characteristic, without regard for engine power and torque characteristics, will not meet this Specification. These characteristics shall be demonstrable as follows:

1. With engine-generator set operating at rated speed, voltage and load, reduce engine speed to half rated by manually overriding engine speed governor control. Engine-generator set must recover to full speed with rated load connected when engine speed governor control is returned to its normal mode.

2. Calculations must demonstrate that exciter and voltage regulator will permit utilization of at least 80 percent of maximum available prime torque at all engine speeds between 50 percent and rated speed, and with rated unity power factor load connected to its terminals.

G. Exciter shall be 3-phase, full-wave, rectified with heavy-duty silicon diodes mounted on common rotor shaft and sized for maximum motor starting loads. Systems utilizing 3 wire solid-state control elements, such as transistors or SCR’s rotation on rotor are not permitted.

H. Generator design shall be of self-protecting type, as demonstrated by prototype short-circuit test as described herein. All other generator performance criteria shall meet that of specified equipment.

I. When engine-generator sets will be paralleled with another source, each set shall be furnished with a cross-current compensation control and rotating exciter transient suppressors.

2.3 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.
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.

### 2.4 ENGINE-GENERATOR SET CONTROLS

A. Provide a lighted, unit-mounted control module that is factory built, wired, tested, and shock-mounted by generator manufacturer. Control module shall be installed on generator end of set. Control wires between generator set and transfer switches shall be provided with termination identification on both ends. Identification shall be provided for each device or function and shall be silk-screened white on a black background.

B. Engine-generator set controls shall be provided with the following for each unit:

1. Gauges and Meters: Oil pressure gauge, coolant temperature gauge, charge rate ammeter and running time meter.
5. Automatic engine shut down for following fault conditions:
   
   a. Overcrank.
   b. Overspeed.
   c. Low lube oil pressure.
   d. High engine temperature.

6. Indicator lamps shall signal the following faults or status conditions:

   a. Overcrank: Indicates starter has been locked out because cranking time was excessive.
b. Overspeed: Indicates engine has shut down because of excessive rpm.
c. High engine temperature: Indicates engine has shut down because of critically high temperature.
d. Low oil pressure: Indicates engine has shutdown because of critically low oil pressure.
e. Pre-high engine temperature: Indicates engine temperature is marginally high.
f. Pre-low oil pressure: Indicates oil pressure is marginally low.
g. Low engine temperature: Indicates engine temperature is marginally low for starting.
h. Switch off (flashing): Indicates control switch is in stop position.
i. Low fuel: Indicates fuel supply is marginally low.
j. Provide 2 spare fault condition lamps.

7. Provide a fault reset switch to clear fault indications and allow restarting of engine after shutdown faults. Control design shall be such that fault indication shall remain until reset. Fault indicator memory shall not be dependent on presence of either AC or DC voltage and shall retain fault status memory even though complete removal and replacement of starting batteries. Fault reset function shall operate only when run-stop-remote switch is in the stop position.

8. Provide a locking screwdriver type potentiometer (electronic governor) to adjust speed plus or minus 2 percent from rated value.

9. Provide AC voltmeter, 90 degree scale, 2-1/2 inch flange, 2 percent switchboard meter.

10. Provide frequency meter 45-65 Hz, 90 degree scale 201/2 inch flange, lus or minus 0.6 Hz panel meter.

11. Provide 4-position AC meters phase selector switch to read line current and voltage in each phase with off position.


2.5 AUXILIARY EQUIPMENT

A. Starting Batteries: Provide battery(ies) as required by manufacturer. Install battery(ies) in racks within engine-generator set skidbase.

B. Battery Chargers: Voltage regulated battery chargers shall be provided for engine-generator sets. Chargers shall be furnished with float, taper, and equalize charge settings. Charger power shall be supplied from normal source; provide circuits as required.

C. Vibration Isolators: Each engine-generator set shall be installed on vibration isolators external to set skidbase.

D. Remote Audible Annunciator: Provide remote audible annunciator with silence alarm feature and a light emitting diode (LED) indicator. The remote annunciator shall provide a common alarm indication of all engine related status conditions or faults as specified under Section 2.4 B-6 of these specifications.
2.6 FUEL OIL STORAGE

A. Comply with NFPA 30.

B. Day Tank: Comply with UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:

1. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day 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 recommended by engine manufacturer for an uninterrupted period of 4 hours' operation at 100 percent of rated power output of engine-generator system without being refilled.

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. 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.

6. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve.

7. Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in day tank to operate a separate motor device that disconnects day-tank pump motor. Sensor shall signal solenoid valve, located in fuel suction line between fuel storage tank and day tank, to close. Both actions shall remain in shutoff state until manually reset. Shutoff action shall initiate an alarm signal to control panel but shall not shut down engine-generator set.

C. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:

1. Tank level indicator.
2. Capacity: Fuel for eight hours' continuous operation at 100 percent rated power output.
3. Vandal-resistant fill cap.

2.7 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 gauges shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.

D. Configuration: Operating and safety indications, protective devices, basic system controls, engine gauges, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components shall be grouped in a combination control and power panel. Control and monitoring section of panel shall be isolated from power sections by steel barriers. Panel features shall include the following:

2. Switchboard Construction: Freestanding unit complying with Section 262413 "Switchboards."
3. Switchgear Construction: Freestanding unit complying with Section 262300 "Low-Voltage Switchgear."

E. Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 2 system, and the following:

1. AC voltmeter.
2. AC ammeter.
3. AC frequency meter.
4. DC voltmeter (alternator battery charging).
5. Engine-coolant temperature gauge.
6. Engine lubricating-oil pressure gauge.
7. Running-time meter.
9. Generator-voltage adjusting rheostat.
10. Fuel tank derangement alarm.
11. Fuel tank high-level shutdown of fuel supply alarm.
12. Generator overload.
F. 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 gauge.
6. Engine lubricating-oil pressure gauge.
7. Running-time meter.
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.

G. 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.

H. 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 260913 "Electrical Power Monitoring and Control."

I. 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.

J. 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.
5. Engine high-temperature prealarm.
6. Lube-oil, low-pressure prealarm.
7. Fuel tank, low-fuel level.
8. Low coolant level.

K. 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.

L. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.8 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 100 percent rated; complying with NEMA AB 1 and UL 489.

1. Tripping Characteristic: Designed specifically for generator protection.
2. Trip Rating: Matched to generator rating.
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 Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

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.

C. Generator Disconnect Switch: Molded-case type, 100 percent rated.

1. Rating: Matched to generator output rating.
2. Shunt Trip: Connected to trip switch when signaled by generator protector or by other protective devices.

D. 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.

E. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

2.9 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.
2.10 LOAD BANK

A. Description: Permanent, outdoor, weatherproof, remote-controlled, forced-air-cooled, resistive or resistive and reactive unit capable of providing a balanced 3-phase, delta-connected load to generator set at 100 percent rated-system capacity at 80 percent power factor, lagging. Unit may be composed of separate resistive and reactive load banks controlled by a common control panel. Unit shall be capable of selective control of load in 25 percent steps and with minimum step changes of approximately 5 and 10 percent available.

B. Resistive Load Elements: Corrosion-resistant chromium alloy with ceramic and steel supports. Elements shall be double insulated and designed for repetitive on-off cycling. Elements shall be mounted in removable aluminized-steel heater cases.

C. Reactive Load Elements: Epoxy-encapsulated reactor coils.

D. Load-Bank Heat Dissipation: Integral fan with totally enclosed motor shall provide uniform cooling airflow through load elements. Airflow and coil operating current shall be such that, at maximum load, with ambient temperature at the upper end of specified range, load-bank elements operate at not more than 50 percent of maximum continuous temperature rating of resistance elements.

E. Load Element Switching: Remote-controlled contractors switch groups of load elements. Contactor coils are rated 120 V. Contactors shall be located in a separate NEMA 250, Type 3R enclosure within load-bank enclosure, accessible from exterior through hinged doors with tumbler locks.

F. Contactor Enclosures: Heated by thermostatically controlled strip heaters to prevent condensation.

G. Load-Bank Enclosures: NEMA 250, Type 3R, complying with NEMA ICS 6. Louvers at cooling-air intake and discharge openings shall prevent entry of rain and snow. Openings for airflow shall be screened with 1/2-inch-square, galvanized-steel mesh. Reactive load bank shall include automatic shutters at air intake and discharge.

H. Protective Devices: Power input circuits to load banks shall be fused, and fuses shall be selected to coordinate with generator circuit breaker. Fuse blocks shall be located in contactor enclosure. Cooling airflow and overtemperature sensors shall automatically shut down and lock-out load bank until manually reset. Safety interlocks on access panels and doors shall disconnect load power, control, and heater circuits. Fan motor shall be separately protected by overload and short-circuit devices. Short-circuit devices shall be noninterchangeable fuses with 200,000-A interrupting capacity.

I. Remote-Control Panel: Separate from load bank in NEMA 250, Type 1 enclosure with a control power switch and pilot light, and switches controlling groups of load elements.
J. Control Sequence: Control panel may be preset for adjustable single step loading of generator during automatic exercising.

2.10 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 preengineered walk-in enclosure with the following features:

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.
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: Within enclosure.

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.

2.11 MOTORS

A. General requirements for motors are specified in contract documents.

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.

2.12 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolation Pads:

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 the product indicated on Drawings or comparable product by one of the following:

   a. Ace Mountings Co., Inc.
   b. California Dynamics Corporation.
   c. Isolation Technology, Inc.
   d. Kinetics Noise Control, Inc.
   e. Mason Industries, Inc.
   f. Vibration Eliminator Co., Inc.
   g. Vibration Isolation.
   h. Vibration Mountings & Controls, Inc.
   i. Or Approved Substitute.

3. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.

4. Size: Factory or field cut to match requirements of supported equipment.

5. Pad Material: Oil and water resistant with elastomeric properties.


7. Infused nonwoven cotton or synthetic fibers.

8. Load-bearing metal plates adhered to pads.

9. Sandwich-Core Material: Resilient and elastomeric.

   a. Surface Pattern: Smooth pattern.
   b. Infused nonwoven cotton or synthetic fibers.

B. Restrained Spring Isolators: Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:
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 the product indicated on Drawings or comparable product by one of the following:
   a. Ace Mountings Co., Inc.
   b. California Dynamics Corporation.
   c. Isolation Technology, Inc.
   d. Kinetics Noise Control, Inc.
   e. Mason Industries, Inc.
   f. Vibration Eliminator Co., Inc.
   g. Vibration Isolation.
   h. Vibration Mountings & Controls, Inc.
   i. Or Approved Substitute

3. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with non-adjustable snubbers to limit vertical movement.
   a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
   b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.

4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

5. Minimum Additional Travel: 50 percent of the required deflection at rated load.


7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.13 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.14 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.

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.
7. Safety shutdown.
8. Provide 14 days' advance notice of tests and opportunity for observation of tests by Engineer or Engineer's representative.
9. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 PERMITS

A. Contractor shall apply and obtain from any regulatory agency having jurisdiction all necessary permits to construct and operate diesel generators with more than 50 brake horsepower ratings.

B. Contractor shall pay all fees or costs associated with obtaining the construction and operations permit(s); provide all labor necessary to demonstrate full compliance with all applicable codes and regulations to secure and deliver to the Campus Maintenance and Operation Energy Unit a valid permit to operate the installed generator. Permit(s) shall be procured at start of construction.

3.2 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.
3.3 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 on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in contract documents.
   1. Comply with requirements for seismic control devices specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."
   2. Comply with requirements for vibration isolation devices specified in this Section.

D. Install remote radiator with elastomeric isolator pads or 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 or remote radiator.

F. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet. Flexible connectors and steel piping materials and installation requirements as specified.
   1. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints.

G. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.4 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 remote radiator or 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 as shown in plans.
2. LP-gas piping, valves, and specialties for gas piping are specified in contract documents.

F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 IDENTIFICATION

A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections 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. Perform tests and inspections and prepare test reports.

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. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection (except those indicated to be optional) 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.
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.

E. Coordinate tests with tests for transfer switches and run them concurrently.

F. 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.

G. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

H. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

I. Test and adjust controls and safety. Replace damaged and malfunctioning controls and equipment.

J. Remove and replace malfunctioning units and retest and reinspect as specified above.

K. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
L. 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.

M. 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.

3.7 TESTING

A. A 48 hour notice shall be provided to the IOR before final testing.

B. Installer is responsible for identifying required testing, coordinating, scheduling and conducting tests before Substantial Completion. Test shall include the following:

1. Perform separate series of tests as follows:

   a. Factory Prototype Model Tests: Electric generating system consisting of prime mover, generator, governor, coupling, and controls must have been tested as complete unit on representative engineering prototype model as required by NFPA 110. Tests, being potentially damaging to the equipment tested, must not be performed on equipment to be sold, but on separate prototype models as specified by NFPA 110, Paragraph 3-2.1 thru 3-2.1.2 and their accomplishment certified by means of documentation of tests accompanying submittal data. These tests shall include:

      1) Maximum power level (maximum KW).
      2) Maximum motor starting capacity (maximum KVA and voltage dip recovery within 7 cycles of applied load).
      3) Load bank(s).
      4) Structural soundness (short-circuit and endurance tests).
      5) Torsiograph analysis: Manufacturer of engine-generator set verify that engine-generator combination as configured, is free from harmful torosional stresses. Analysis shall include correlation of empirical data from tests on a representative prototype unit. Empirical data must include spectrum analysis.
of torosional transducer output within critical speed range of engine-generator set. Results of this analysis shall be made available to Engineer on request. Calculations based on engine and generator separately are not permitted.

6) Engine-generator cooling air requirements.
7) Transient response and steady-state speed control and voltage regulation.
8) Generator temperature rise per NEMA MG-22.40.
9) Harmonic analysis and voltage waveform deviation per MIL-STD-705B, method 601.4.
10) Three-phase short-circuit test for mechanical and electrical strength. With system operating at rated volts, amps, power factor, and speed, generator terminals must be short circuiting 10 times on all 3 phase for a duration of 30 seconds. Engine-generator set must build up and perform normally without manual interventions of any kind such as resetting or circuit breakers or other tripping devices when short circuit is removed.
11) Failure mode test for voltage regulator: With engine-generator set operating at no load, rated speed and voltage, AC sensing circuit to regulator must be disconnected for a period of at least one hour. Engine-generator set must be fully operative after test, and without evidence of damage.
12) Endurance testing is required to detect and correct potential electrical and mechanical problems associated with typical operation.
13) Full load test conducted at the specified ambient temperature for at least four hours. The test results shall identify all components and performance data for 0-to-50%, 0-to-100%, and 50-100% instantaneous load applications.
14) Steady state performance shall be recorded at 15 minute intervals; test shall be performed for four hours minimum at 100% rating, with load characteristics of 80% power factor and total harmonic distortion of 50%.
15) Results shall include oil pressure, oil temperature, coolant temperature, fuel pressure, ambient temperature, load in KW, KVA, amperes, output voltage, and load characteristics, which are required to be sinusoidal with a minimum 80% power factor.
16) Included in the generator cost shall be a fully paid trip for the Engineer or the Engineer's Representative to witness factory test. This shall include travel and lodging as necessary.

b. Factory Production Model Tests: Before shipment of equipment, engine-generator sets shall be tested under rated loads and power factor for performance and proper functioning of control and interfacing circuits. Testing at unity power factor, and the KVAR for motor starting and regulation loads varies with power factor. Tests shall include:

1) Single step load pickup per NFPA 110, Paragraph 5-13.2.6.
EMERGENCY GENERATOR AND DATA CENTER HVAC UPGRADES

2) Transient and voltage dip responses and steady state voltage and speed (frequency) checks.
3) Fuel consumption (no-load, 1/4 load, 1/2 load, 3/4 load, and full load).
4) Load bank(s).
5) Generator temperature rise by resistance method.
6) Engineer has the option of witnessing these tests. A summary of test results shall be submitted to the IOR.
7) For paralleling applications manufacturer shall have performed and certified that engine-generator sets can withstand 180 degrees out-of-phase from full rated voltage and speed without sustaining any mechanical or electrical damage.

c. Field Tests After Installation:

1) Complete installation shall be initially started and observed for operational compliance by factory-trained representatives of engine-generator set manufacturer. Engine lubrication oil and as recommended by manufacturer for operation under environmental conditions specified, shall be provided by engine-generator sets supplier.

2) Upon completion of initial start-up and system checkout, supplier of system shall perform a field test, with Engineer and IOR notified in advance, to demonstrate load carry capability and voltage and frequency stability.

3) With emergency load, at normal operating level, a power failure is initiated by opening switches or breakers supplying normal power to building or facility. Records shall be maintained throughout tests of time-of-day, coolant temperature, cranking time until prime mover starts and runs, time required to come up to operating speed, voltage and frequency overshoot, time required to achieve steady-state condition with switches transferred to emergency position, voltage, frequency, current, oil pressure, ambient air temperature, kilowatts, power factor, battery charger rate at 5 minute intervals for first 15 minutes, and at 15 minute intervals thereafter. Continue this load test for 2 hours observing and recording load changes and resultant effect on voltage and frequency. Return to normal power, record time delay on re-transfer for each switch (set for 15 minutes minimum) and time delay on prime mover cooldown period and shutdown.

4) Upon completion of above test, allow prime mover to cool for 5 minutes. Then apply full rated load (nameplate KW) consisting of building load supplemented by a load bank if required. Unity power factor is suitable for Project site testing; provided that rated load tests at power factor have been performed by manufacturer before shipment. This full-load pickup shall be in one step immediately upon reaching rated rpm.
5) Provide a four-hour full load field test of generator.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

3.9 TRAINING

A. Before Substantial Completion, provide the services of a manufacturer's representative on the Project site to instruct persons designated by the Owner in the operation and maintenance of the system. Instruction time shall not be less than 1 day.

B. Manufacturer shall have a local representative who can provide factory-trained technicians, required stock of replacement parts, and technical assistance.

C. Contractor to schedule with Campus Engineer thru the Project Manager for load testing and Emergency Power System training.

3.10 SERVICE CONTRACT

A. Provide an agreement whereby the system will be inspected and tested by manufacturer in accordance with NFPA 110 emergency and standby power systems. Testing shall be conducted by a local factory trained technician who will, upon completion of testing, provide the Owner with written records of visual inspections and testing. This agreement shall be in effect for a period of 2 years after Substantial Completion of the Work. Cost of service contract shall be included as a part of this Contract.

3.11 PROTECTION

A. Protect the Work of this section until Substantial Completion.

3.12 CLEANUP

A. Remove rubbish, debris, and waste materials and legally dispose of off the Project site.

END OF SECTION 263213
SECTION 263600 – AUTOMATIC LOAD TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes: Provide complete and operable automatic load transfer switches, including devices and equipment specified herein, indicated on Drawings, or required for service. Materials and equipment shall be delivered to the Project site completely wired, tested, and ready for installation.

B. Related Requirements:

1. All contract documents.

1.3 DESIGN REQUIREMENTS

A. Transfer switches shall be designed, built, tested, furnished and warranted by manufacturer for installation with emergency generator specified under Section 263213 “Engine Generators.” The transfer switch manufacturer shall have been regularly engaged in production of the products of this section for 10 years in accordance with Underwriter’s Laboratories (UL) Standard 1008. Transfer switches shall comply with NFPA 110 and NEMA ICS 2-447 requirements.

B. Provide auxiliary contacts on the transfer switch and utilize the EMS to monitor and control, switch operation.

C. Provide two positions maintained contact switch on the automatic transfer switch: “Test” and “Automatic.” The “Test” position simulates power failure with transfer to “emergency” position. To prevent the unauthorized operation of exterior mounted switches, test switch shall be either key operated or contained in a locked area.

D. Exterior mounted automatic transfer switches shall contain a thermostatically controlled strip heater.
1.4 ACCEPTABLE MANUFACTURERS

A. Automatic transfer switches shall be Cummins Power Generation OTPC transfer switches or Approved Substitute. Any alternate shall be submitted to the consulting engineer in writing at least 10 days prior to bid. Each alternate bid must list any deviations from this specification.

1.5 CODES AND STANDARDS

A. The automatic transfer switches and accessories shall conform to the requirements of:

1. UL 1008 – Standard for Automatic Transfer Switches.
2. NFPA 70 – National Electrical Code.
3. NFPA 110 – Emergency and Standby Power Systems
5. NEMA Standard ICS10-1993 (formerly ICS2-447) – AC Automatic Transfer Switches
6. NEC Articles 700, 701, 702

1.6 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.

C. Qualification Data: For manufacturer and testing agency.

D. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Section 260548 "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.

E. Submit literature containing diagrams, parts lists and descriptions as required to install, operate and perform normal maintenance on equipment.

F. Materials List: Submit a materials list for system with catalog cuts, technical data and manufacturer’s specifications.

G. Installation Instructions: Submit manufacturer’s written installation instructions, including recommendations for handling, protection and storage.

H. Field quality-control reports.

I. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. 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.

1.7 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 (NETA) 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, bypass/isolation switches, remote annunciator, and remote annunciator and control panels through one source from a single manufacturer.

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

E. Equipment shall be manufactured by a single manufacturer who has been regularly engaged in the production of automatic load transfer switches.
Transfer switches shall be factory built, factory tested, and shipped by this single manufacturer, so there is one source of supply and responsibility for warranty, parts, and service. Manufacturer shall have a local representative who can provide factory trained technicians, required stock of replacement parts, and technical assistance.

F. Equipment as described herein is that as manufactured by Cummins Power Generation. Equipment furnished shall be or equal to that specified herein, including quality, operation, and function.

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:

1. Notify Engineer, Construction Manager and Owner no fewer than two days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Engineer’s, Construction Manager’s and Owner’s written permission.

1.9 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are as specified.

1.10 WARRANTY

A. Manufacturer shall provide a 5 year material warranty.

PART 2 - PRODUCTS

2.1 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 4 to plus 158 deg F.

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 600 A and higher, shall have segmented, blow-on construction for high withstand current capability and be protected by separate arcing contacts.

G. Neutral Switching: Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.

H. Neutral Terminal: Solid and fully rated, unless otherwise indicated.

I. Oversize Neutral: Amperage and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.

J. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.

K. Battery Charger: For generator starting batteries.

1. Float type rated 2 or 10 A.
2. Ammeter to display charging current.
3. Fused ac inputs and dc outputs.

L. 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.

M. 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 260553 "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.

N. Enclosures:

1. General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.
2. Provide strip heater with thermostat for Type 3R enclosure requirements.
3. Controller shall be flush-mounted display with LED indicators for switch position and source acceptability. It shall also include test and time delay bypass switches.

2.2 MECHANICALLY HELD TRANSFER SWITCH

A. The transfer switch unit shall be electrically operated and mechanically held. The electrical operator shall be a single-solenoid mechanism, momentarily energized. Main operators which include overcurrent disconnect devices will not be accepted. The switch shall be mechanically interlocked to ensure only one of two possible locations, normal or emergency.

B. The switch shall be positively locked and unaffected by momentary outages so that contact pressure is maintained at a constant value and temperature rise at the contacts is minimized for maximum reliability and operating life.

C. Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. A manual operating handle shall be provided for maintenance purposes. The handle shall permit the operator to manually stop the contacts at any point throughout their entire travel to inspect and service the contacts when required.

D. Designs utilizing components of molded-case circuit breakers, contactors, or parts thereof which are not intended for continuous duty, repetitive switching or transfer between two active power sources are not acceptable.

E. Where neutral conductors must be switched, the ATS shall be provided with fully-rated neutral transfer contacts.

F. Where neutral conductors are to be solidly connected, a neutral terminal plate with fully-rated AL-CU pressure connectors shall be provided.
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.


E. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of 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. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.

H. Automatic Closed-Transition Transfer Switches: Include the following functions and characteristics:

1. Fully automatic make-before-break operation.
2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.
   a. Initiation occurs without active control of generator.
   b. Controls ensure that closed-transition load transfer closure occurs only when the 2 sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.

4. Failure of power source serving load initiates automatic break-before-make transfer.

I. 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.
J. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.

K. Programmed Neutral Switch Position: Switch operator has a programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Pause is adjustable from 0.5 to 30 seconds minimum and factory set for 0.5 second, unless otherwise indicated. Time delay occurs for both transfer directions. Pause is disabled unless both sources are live.

L. 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.


   a. Normal Power Supervision: Green light with nameplate engraved "Normal 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 BYPASS/ISOLATION SWITCHES

A. Comply with requirements for Level 1 equipment according to NFPA 110.

B. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
   1. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transfer-switch operation, except for testing or maintenance.
   2. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations.
   3. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
   4. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
   5. Operability: Constructed so load bypass and transfer-switch isolation can be performed by 1 person in no more than 2 operations in 15 seconds or less.
   6. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
7. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.

C. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

2.5 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.

2.6 REMOTE ANNUNCIATOR AND 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. Remote Annunciation and Control Panel: Solid-state components. Include the following features:

1. Controls and indicating lights grouped together for each transfer switch.
2. Label each indicating light control group. Indicate transfer switch it controls, location of switch, and load it serves.
3. Digital Communication Capability: Matched to that of transfer switches supervised.
4. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.

2.7 MICROPROCESSOR CONTROLLER WITH MEMBRANE INTERFACE PANEL

A. The controller shall direct the operation of the transfer switch. The controller’s sensing and logic shall be controlled by a built-in microprocessor for maximum reliability, minimum maintenance, and inherent serial communications capability. The controller shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the controller to be disconnected from the transfer switch for routine maintenance.

B. The controller shall be enclosed with a protective cover and be mounted separate from the transfer switch unit for safety and ease of maintenance. Sensing and control logic shall be provided on printed circuit boards. Interfacing relays shall be industrial grade plug-in type with dust covers.

C. The controller shall meet or exceed the requirements for Electromagnetic Capability (EMC) as follows:

1. ANSI C37.90A/IEEE 472 Voltage Surge Test.
2. NEMA ICS – 109.21 Impulse Withstand Test.
3. IEC 801 – 2 Electrostatic discharge (ESD) immunity.
4. ENV50140 and IEC 801 – 3 Radiated electromagnetic field immunity.
5. IEC 801 – 4 Electrical fast transient (EFT) immunity.
6. ENV50142 Surge transient immunity.
7. ENV50141 Conducted radio-frequency field immunity.
8. ENV55011 Group 1, Class A conducted and radiated emissions
9. EN61000 – 4 – 11 Voltage dips and interruptions immunity.

2.8 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 - OPERATION

3.1 VOLTAGE AND FREQUENCY SENSING

A. The voltage of each phase of the normal source shall be monitored, with pickup adjustable to 95 percent of nominal and dropout adjustable from 70 to 90 percent of pickup setting.

B. Single-phase voltage and frequency sensing of the emergency source shall be provided.

3.2 TIME DELAYS

A. An adjustable time delay shall be provided to override momentary normal source outages and delay all transfer and engine starting signals.

B. An adjustable time delay shall be provided on transfer to emergency, adjustable from 0 to 5 minutes for controlled timing of transfer of loads to emergency.

C. A generator stabilization time delay shall be provided after transfer to emergency.

D. An adjustable time delay shall be provided on retransfer to normal, adjustable to 30 minutes. Time delay shall be automatically bypassed if emergency source fails and normal source is acceptable.

E. A 5-minute cooldown time delay shall be provided on shutdown of engine generator.

F. All adjustable time delays shall be field adjustable without the use of special tools.

3.3 ADDITIONAL FEATURES

A. A set of contacts rated 5 A, 32 V-dc shall be provided for a low-voltage start signal. The start signal shall prevent dry cranking of the engine by requiring the generator set to reach proper output, and run for the duration of the cool down setting, regardless of whether the normal source restores before the load is transferred.

B. A push-button type test switch must be provided to simulate a normal source failure.

C. A push-button type switch to bypass the time delay on transfer to emergency, the engine exerciser period on the retransfer to normal time delay whichever delay is active at the time the push-button is activated.
D. Terminals shall be provided for a remote contact which opens to signal the ATS to transfer to emergency and for remote contacts which open to inhibit transfer to emergency and/or retransfer to normal.

E. Auxiliary contacts, rated 10 A, 250 V-ac shall be provided consisting of one contact, closed when the ATS is connected to the normal source and one contact, closed, when the ATS is connected to the emergency source.

F. Indicating lights shall be provided, one to indicate when the ATS is connected to the normal power source (green) and one to indicate when the ATS is connected to the emergency source (red). Also provide indicating lights for both normal and emergency source availability.

G. Terminals shall be provided to indicate actual availability of the normal and emergency sources, as determined by the voltage sensing pickup and dropout settings for each source.

H. Engine Exerciser – An engine generator exercising timer shall be provided including a selector switch to select exercise with or without load transfer.

I. Inphase Monitor – An Inphase monitor shall be inherently built into the controls. The monitor shall control transfer so that motor load inrush currents do not exceed normal starting currents, and shall not require external control of power sources. The Inphase monitor shall be specifically designed for and be the product of the ATS manufacturer.

J. Selective Load Disconnect – A double throw contact shall be provided to operate after a time delay, adjustable to 20 seconds prior to transfer and reset 0 to 20 seconds after transfer. This contact can be used to selectively disconnect specific load(s) when the transfer switch is transferred. Output contacts shall be rated 6 A at 28 V-dc or 120 V-ac.

PART 4 - ADDITIONAL REQUIREMENTS

4.1 WITHSTAND AND CLOSING RATINGS

A. The ATS shall be rated to close on and withstand the available RMS symmetrical short circuit current at the ATS terminals with the type of overcurrent protection shown on the plans. WCR ATS ratings shall be as follows when used with specific circuit breakers:

1. ATS Size: 30
   a. Withstand & Closing Rating MCCB: 22,000 A
   b. W/CLF: 100,000

2. ATS Size: 70 – 200
   a. Withstand & Closing Rating MCCB: 22,000 A
b. W/CLF: 200,000

3. ATS Size: 230
   a. Withstand & Closing Rating MCCB: 22,000 A
   b. W/CLF: 100,000

4. ATS Size: 260 – 400
   a. Withstand & Closing Rating MCCB: 42,000 A
   b. W/CLF: 200,000

5. ATS Size: 600 – 1200
   a. Withstand & Closing Rating MCCB: 65,000 A
   b. W/CLF: 200,000

6. ATS Size: 1600 – 2000
   a. Withstand & Closing Rating MCCB: 85,000 A
   b. W/CLF: 200,000

7. ATS Size: 2600 – 3000
   a. Withstand & Closing Rating MCCB: 100,000 A
   b. W/CLF: 200,000

4.2 SERVICE REPRESENTATION

A. The ATS manufacturer shall maintain a national service organization of company-employed personnel located throughout the contiguous United States. The service center’s personnel must be factory trained and must be on call 24 hours a day, 365 days a year.

B. The manufacture shall maintain records of each switch, by serial number, for a minimum of 20 years.

C. For ease of maintenance, the transfer switch nameplate shall include drawing numbers and serviceable part numbers.

PART 5 - EXECUTION

5.1 INSTALLATION

A. Install automatic load transfer switches as indicated on Drawings and in accordance with installation instructions.
B. Provide remote start with status connection from the Campus Energy Management System (EMS).

C. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Section 260548 "Vibration and Seismic Controls for Electrical Systems."

D. 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 260529 "Hangers and Supports for Electrical Systems."

E. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.

F. Identify components according to Section 260553 "Identification for Electrical Systems."

G. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

5.2 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 260526 "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

5.3 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 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.

   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.

4. 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. Simulate loss of phase-to-ground voltage for each phase of normal source.
   c. Verify time-delay settings.
   d. Verify pickup and dropout voltages by data readout or inspection of control settings.
   e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
   f. 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.
   g. 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.

5. 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. Testing Agency's Tests and Inspections:

1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
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.

4. 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. Simulate loss of phase-to-ground voltage for each phase of normal source.
   c. Verify time-delay settings.
   d. Verify pickup and dropout voltages by data readout or inspection of control settings.
   e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
   f. 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.
   g. 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.

5. 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.

5.4 TESTING

A. To provide proven reliability of system, transfer switches shall be completely tested as follows:

1. Representative production samples of transfer switches supplied, shall be demonstrable, through tests, ability to withstand at least 3,000 mechanical operating cycles. An operating cycle shall consist of one electrically operated transfer from normal to emergency and back to normal.

2. During development of original transfer switching mechanism for this family of transfer switches, a prototype of transfer switching mechanism shall have passed environmental tests listed in Military Standard, Mil-Std-202 202 F. Test shall include Method 101D-Condition B, Salt Spray-Corrosion; Method 103B-Condition B, Humidity; Method 107D-Condition A, Thermal Shock; Method 110A Sand and Dust.

3. Transfer switches shall be UL, or other NRTL listed in accordance with Standard 100B.
   a. Transfer switches shall have minimum withstand and closing ratings (RMS symmetrical amperes) as required for the available fault currents shown on drawings. These ratings shall be obtained without contact welding. These fault current ratings shall be verified by UL witnessed test on representative test samples and shall be the ratings listed in the UL listing or component recognition procedures for the transfer switches supplied.
   b. Where the line side over-current protection is provided by molded case circuit breakers at 480 V-ac or less, the circuit breakers shall be of the type specified by the manufacturer with the maximum size not exceeding the maximum ratings listed in the UL listing or component recognition procedures for transfer switches supplied.
   c. Where the line side over-current protection is provided by current limiting fuses, the fuses shall be UL, or other NRTL, Class RK1, RK5, J or L (with fuse sizes not larger than maximum ratings listed in the UL listing or component recognition procedures for transfer switches supplied), and the transfer switches withstand and closing rating shall be suitable for 200,000 amperes available fault current.

4. RMS symmetrical fault current ratings shall be verified by UL or other NRTL witnessed tests on representative test samples. WCR test shall be performed with over-current protective devices located external to transfer switch. Test conducted with over-current protective devices internal to transfer switch, in such a manner that transfer switch interrupts current rather than withstanding current, are not acceptable under this definition of withstand.
5. A manufacturer’s representative shall conduct a complete system operation test at the Project site, in presence of the IOR, after installation.

5.5 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.

B. Coordinate this training with that for generator equipment.

5.6 TRAINING

A. Before Substantial Completion, provide the services of a representative of the transfer system manufacturer to instruct designated Owner personnel in the operation and maintenance of system. Instruction time shall be not less than 1 day.

B. Coordinate training with OAR and area electrical supervisor to arrange a 4 hour minimum training session, a minimum of 4 sets of manuals and training literature shall be made available for M&O personnel.

C. A training guide shall be included as part of project’s final deliverables and close out package.

D. Contractor to schedule with Campus Engineer through the Project Manage for load testing and Emergency Power System training.

5.7 AS-BUILT DOCUMENTATION

A. Submit service manuals including the following:

1. Detailed explanation of the operation of the system.
2. Instructions for routine maintenance.
3. Detailed instructions for repair of major components of the system.
4. Pictorial parts list and part numbers.
5. Pictorial and schematic electrical drawings of wiring systems, including operating and safety devices, and major components.
6. Installation instructions for system components.
7. Final test report.
8. Reproducible set of record drawings showing the system exactly as it was installed including exact location of components.

5.8 PROTECTION

A. Protect the Work of this section until Substantial Completion.
5.9 CLEANUP

A. Remove rubbish, debris and waste materials and legally dispose of off the Project site.

END OF SECTION 263600
PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, material and equipment required for placement and amendment of topsoils for areas to be planted, and the establishment of finish grades as shown on the Drawings and as specified herein. Also furnish labor, material and equipment to install 3 inch perforated drain pipe rings and tight line connections to storm drains at the planting pits of each crape myrtle and in areas shown on Drawings.

B. Coordinate work with installation of other site work including earthwork, irrigation, seeding, and planting.

1.2 DEFINITIONS

A. Finish Grade: Elevation of finished surface of amended topsoil soil.

B. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.

C. Amended Topsoil: Native or imported topsoil or surface soil modified with soil amendments and fertilizers.

D. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill, before placing planting soil.

E. Topsoil: See Part 2 — Products.

1.3 SUBMITTALS

A. Product Data. Include Material Safety Data Sheets (MSDS) where applicable: For the following:

1. Fertilizers, including application rates.
2. Soil Amendments.
3. Herbicides.

B. Samples for Verification: For the following:

1. 1/2 cubic foot compost.
2. 1/2 cubic foot of each imported topsoil. Furnish one sample from each site from which soil is to be furnished.
C. Product Certificates: For each type of manufactured product, signed by product manufacturer, and complying with the following:

1. Manufacturer’s certified analysis for standard products.
2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.

D. Qualification Data: For testing agencies.

E. Material Test Reports:

1. Soil Fertility and Agricultural Suitability Analyses and Recommendations Reports for the following:
   a. Existing on-site topsoil: From three typical locations as selected by Owner’s Representative, minimum 30 days prior to beginning soil preparation work.
   b. Imported topsoil: Minimum 30 days prior to beginning soil preparation work.
   c. Amended soils: Test samples from 3 typical locations as selected by Owner's Representative, minimum 10 days after soil preparation work has been completed, and prior to planting.

2. Compost Analysis: Provide analysis for one representative sample of compost intended to be provided a minimum 30 days prior to compost being delivered to Project Site.
3. Soil Compaction Test: Provide results of soil compaction tests minimum of 7 days prior to planting and seeding.

F. Delivery Slips: Provide delivery slips as proof of shipment of specified materials.

1.4 QUALITY ASSURANCE

A. Soil Fertility and Agricultural Suitability-Testing Laboratory Qualifications: An independent laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

1. Acceptable Soil Testing Laboratories are:
   a. Soil and Plant Laboratory, Inc., (503) 557-4959.
   b. A & L Western Agricultural Laboratories, (503) 968-9225.
   c. Western Laboratories, Inc, (800) 658-3858.

B. Soil Analyses: Furnish soil analysis by a qualified soil-testing laboratory stating:

1. Soil Composition: USDA particle size analysis indicating percentages of sand, silt and clay, and percent organic matter.
2. Macro and micro nutrient fertility tests as determined by pH, salinity, nitrate nitrogen, ammonium nitrogen, phosphate phosphorous potassium, calcium, magnesium, soluble copper, zinc, manganese, iron, saturation extract boron and sodium analyses.

3. Recommendations by the soil testing lab for fertilizer and soil amendments in pounds per 1,000 square foot or tons per acre, as necessary to correct soil deficiencies.

C. Compost Testing Laboratory Qualifications: An independent laboratory, with the experience and capability to conduct the testing indicated following U.S. Composting Council Seal of Testing Assurance (STA) procedures, or equivalent.

1. Acceptable STA Compost Testing Laboratories are:
   a. A & L Western Agricultural Laboratories, (503) 968-9225.
   b. Control Laboratories, (831) 724-5422.

D. Compost Analysis: Provide documentation from supplier that compost has reached a monitored temperature of 140 degrees Fahrenheit for at least one week. Engage an independent soil testing laboratory to test representative sample(s) of compost and furnish compost analysis report for the following parameters:

1. Percent organic matter, percent moisture, percent inerts (foreign matter), pH, soluble salts, and particle size.
2. Nutrient content, including: Nitrogen (N) Phosphorus (P), Potassium (K), Calcium (Ca), and Magnesium (Tag) and Sulfur (S)
3. Trace Metals, including: Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Mercury (Hg), Nickel (Ni), and Zinc (Zn).
5. Stability Indicator: Provide respiration test results,

E. Request inspection and allow observation by Owner’s Representative of prepared soils before planting,

F. Soil Compaction Testing: Furnish soil compaction standard tests per ASTM 698. Request inspection and allow observation by Owner's Representative of prepared soils before planting.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver packaged materials in manufacturer’s unopened containers fully identified by name, brand, type, weight and analysis.

B. Store and handle packaged materials to prevent damage and intrusion of foreign matter.
C. Store stockpiled topsoil in area designated by Owner’s Representative. Provide erosion control measures for stockpiled topsoil on site to prevent contamination of the soil.

1.6 SOIL AMENDMENT BID QUANTITIES

A. Bid quantities and types of soil amendments shall be based upon those listed in this Section. Types of amendments required and quantities shall be adjusted as necessary based upon actual results of soil fertility and agricultural suitability analyses and recommendations for on-site topsoils.

B. Amount per 1000 square-feet:

1. 25 lbs. Gypsum (Calcium sulfate)
2. 35 lbs. Calcium carbonate limestone ‘Calpril’
3. 35 lbs. Dolomite limestone ‘Dolpril’
4. 8 lbs. Treble superphosphate (0-45-0)
5. 3 lbs. Ammonium nitrate
6. 4 ozs. Zinc sulfate
7. 8 ozs. Manganese sulfate
8. 1 oz. Laundry Borax
9. 6 cu-yds Compost

1.7 SITE CONDITIONS

A. Topsoil placement and soil preparation shall not take place during periods where saturated soil or surface water is present in work areas.

1.8 COORDINATION

A. Coordinate soil preparation such that topsoil, soil amendments and fertilizers are incorporated into ground fill areas in specified lifts to specified depths below finish grade for both planting areas and lawn areas. Topsoils shall be amended per recommendations of the Soils Testing Laboratory.

B. Coordinate work with installation of other site work, including irrigation, seeding, and planting.

PART 2 - PRODUCTS

2.1 TOPSOIL

A. Topsoil Definition: ASTM D 5268; natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles, conforming to USDA classification for Loam or Sandy Loam; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of
subsoil, clay lumps, gravel, and other objects more than 1 inches in any
dimension; and free of weeds, roots, and other deleterious materials, with the
following physical properties:

2. Sodium Adsorption Ratio (SAR): less than 6.0.
3. Saturation Extract concentration for Boron: less than 1.0
4. pH range of from 6 to 8 (plus 0, minus 0.5).
5. Saturation Extract Conductivity: less than 4.0 dS/m @ 77 degrees
   Fahrenheit as determined in a saturation extract.
6. Non-soil components: less than 1 percent by volume.
7. Heavy metal concentrations: below the USDA per year Road limit.
8. Minimal weed seed.

   a. If regenerative noxious weeds (including, but not limited to, quack
      grass, nutsedge grass, and horsetail) are present in the soil, all
      resultant growth including roots shall be removed throughout one-
      year period after acceptance of work at no additional cost to Owner.

B. Topsoil Source: Reuse surface soil stockpiled on-site. Verify suitability of
stockpiled surface soil to produce topsoil. Clean surface soil of roots, plants,
sod, stones, clay lumps, and other extraneous materials harmful to plant
growth. Ensure no contamination of the soils occurs during earthwork and
grading, and that the soil remains friable and free of debris.

1. Import Topsoil: Supplement on-site topsoil with imported or manufactured
topsoil from off-site sources when quantities are insufficient. Obtain
topsoil displaced from naturally well-drained construction or mining sites
where topsoil occurs at least 4 inches deep; do not obtain from
agricultural land, bogs or marshes.

2.2 INORGANIC SOIL AMENDMENTS

A. Dolomitic Lime: Natural, agricultural limestone (calcium and magnesium
carbonate) containing a minimum of 20 percent calcium and 11 percent
magnesium and as follows:

1. Screen Analysis: 100 percent passing through .30 sieve; 70 percent
   passing through No. 100 sieve; and minimum 30 percent passing through
   No.325 sieve.
2. Provide lime in form qranulated, prilled, dolomitc limestone, ‘DoloPril’
   by Pacific Calcium, Inc., (877) 571-3555, or Approved Substitute.

B. Calcitic Lime: Natural, agricultural limestone (calcium carbonate) containing a
minimum of 36 percent calcium and as follows:

1. Screen Analysis: minimum of 100 percent passing through No. 10 sieve
   and a minimum of 80 percent passing through No. 100 sieve.
2. Provide lime in form of granulated, prilled, limestone, ‘CalPril’ by Pacific
   Calcium, Inc., (877) 571-3555, or Approved Substitute.
C. Sulfur: Granular, biodegradable, containing a minimum of 90 percent sulfur, with a minimum of 99 percent passing through No. 6 sieve and a maximum of 10 percent passing through No. 40 sieve.

D. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.

E. Aluminum Sulfate: Commercial grade, unadulterated.

F. Agricultural Gypsum: Finely ground, containing a minimum of 90 percent calcium sulfate, or 85 percent calcium sulfate dihydrate.

G. Sand: Clean washed river sand, free of calcium, chlorides and other deleterious substances.

2.3 ORGANIC SOIL AMENDMENTS

A. Compost: Well-decomposed, commercially manufactured, stable, and weed-free organic matter from agricultural, food, biosolids, or yard debris sources; pH range of 5.5 to 8.0; 100 percent passing through 3/4-inch sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and shall conform as follows:

1. Tested, at minimum, every six months for noxious weeds.
2. Organic matter source (feedstock): Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
3. Organic Matter Content: 60 to 80 percent of dry weight as determined by ash method.
4. Moisture Content: 35 to 55 percent by weight.
5. Free of refuse (less than 1 percent by dry weight), plastics, contaminants or any material toxic to plant growth.
6. Processed to meet U.S. Composting Council’s Seal of Testing Assurance Program, or equivalent.
7. Carbon to Nitrogen Ratio: 40-45 to 1 or lower.
8. Composted for a minimum of 9 months and reach a monitored temperature of 140 degrees Fahrenheit for at least one week.

2.4 FERTILIZER

A. Fertilizer composition and rate of application to be determined based upon soil analysis and deficiencies that may be found. For bidding purposes, assume: 10 Nitrogen (N), 10 Phosphorus (P), 10 Potassium (K), 5 Sulfur (S) applied at a rate of 10 pounds per 1000 square feet in all planting beds and seeded areas.

B. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 1 percent nitrogen and 10 percent phosphoric acid.
C. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.

D. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent of urea formaldehyde, phosphorous, and potassium in the following composition:

1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

E. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium derived from natural organic and inorganic sources in the following composition:

1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

2.5 MISCELLANEOUS PRODUCTS

A. Post-Emergent Herbicide: “Round-Up” by Monsanto or Approved Substitute.

B. Contact Herbicide for controlling nutsedges: “Manage” by Monsanto.

C. 3” Drain Tube and Fittings: Corrugated perforated and non-perforated pipe and associated fittings for drain circles at crape myrtle trees and connection to storm drain system; ADS or Approved Substitute

D. Geotextile Fabric: Fabric of PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. when tested according to ASTM D 4491.

1. Structure Type: Nonwoven, needle-punched continuous filament.
2. Style: Flat.
3. Manufacturer and Product: Propex, Geotex 351; or Approved Substitute.

E. Drain Rock: Washed, narrowly graded mixture of crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 7; with 100 percent passing a 3/4-inch sieve and 0 to 4 percent passing a No. 4 sieve.

PART 3 - EXECUTION

3.1 EXAMINATION OFFSITE CONDITIONS

A. Examine for site conditions that will adversely affect execution, permanence, quality of work, and survival of plant material and grasses.

B. Verify that subgrades and slopes of lawn and planting areas are acceptable to Owner’s Representative prior to commencing work of this Section.
C. Should the Contractor find any discrepancies between the Drawings and the physical conditions, inform the Owner’s Representative immediately for clarification.

D. Begin Work required under this Section only after conditions are satisfactory.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities, and existing lawns and exterior plants from damage caused by soil preparation operations.

B. Prepare soils at a time when moisture conditions will permit proper cultivation.

C. Remove stones over 1-inch diameter, sticks, roots, mortar, concrete, rubbish, debris, and all materials harmful to plant life, and legally dispose of them off Owner’s property.

D. Remove or spray as required to eradicate noxious weed growth and roots.
   1. Achieve complete removal or kill of all weeds within all areas receiving new plantings and lawn areas.
   2. In planting beds, kill achieved by working soil is permissible for annual non-noxious broad-leaf type weeds.
   3. Apply post-emergent herbicide over all areas of weed or grass growth within landscaped area to eradicate weed growth and roots. Apply in two applications at manufacturer’s maximum recommended rate, as follows:
      a. First application: Apply 7 days prior to performing soil preparation.
      b. Second application (to kill new vegetation): Apply after soil preparation has been completed and minimum of 48 hours prior to planting.
      c. Observe manufacturer’s recommended period prior to working in treated areas.
   4. Apply contact herbicide directly onto foliage of nutsedges. In areas of established turf grasses infested with nutsedge, apply herbicide by wicking. Do not spray.

E. Locate and securely mark or flag irrigation sprinkler heads, area d rains, catch basins, clean outs, manholes, valve boxes, and other site improvements not extending above finish grade.

F. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, as specified.
3.3 SOIL PREPARATION FOR PLANTING AREAS

A. This article pertains to those shrub bed areas indicated as “Shrub and Groundcover Planting Areas” on the Drawings where mass plantings of trees, shrubs and ground cover plants are scheduled.

B. Prepare subgrades by excavating and removing soil, rock and other construction material to 15 inches below finish grade. Cross-rip subgrades to depth of 6 inches prior to placing topsoil.

C. Place 6 inches topsoil, compost, soil amendments and fertilizers as recommended in Agricultural Soil Suitability Report per 1,000 square feet and rototill thoroughly to a depth of 8 inches. Place remainder of topsoil, compost, soil amendments and fertilizers as recommended in Agricultural Soil Suitability Report per 1,000 square feet and rototill thoroughly to a depth of 8 inches, allowing for compaction, natural settlement, and depth of specified mulch.

D. Water lightly and allow planting mix to settle. Add additional material at mixture indicated in paragraph above to bring soil level to grades shown on the Drawings with allowance at pavement edges for mulch placement. Provide compaction to 85 percent relative density.

E. Meet lines, grades and elevations shown, after fitting rolling and natural settlement. Fine grade shrub and ground cover areas to smooth even surface with loose, uniformly fine texture. Rake and drag shrub and ground cover areas to remove ridges and fill depressions to obtain firmness and finish grades preparatory to receiving planting.

F. Remove stones over 1/2-inch in any dimension and sticks, roots, rubbish and other extraneous matter.

3.4 SOIL PREPARATION FOR SODDED LAWNS (REPAIRS OR PATCHES)

A. This article pertains to portions of existing lawns as shown on Drawings and grass areas disturbed by construction activities.

B. Prepare subgrades by excavating and removing soil, rock and other construction material to 6 inches below finish grade. Cross-rip subgrades to depth of 6 inches prior to placing topsoil.

C. Place topsoil and compost as recommended in Agricultural Soil Suitability Report per 1,000 square feet. Rototill thoroughly to a depth of 8 inches, titling topsoil into top 2 inch layer of sub-soil. If disturbed or damaged areas being patched are too small to rototill, then prepare subgrade interface by spading or excavating with a pitch fork to a minimum 6 inch depth into subgrade. Thoroughly break up all clods and soil masses so that interface is of a uniform texture. Place sufficient topsoil allowing for compaction and natural settlement.

D. Place remaining soil amendments, and fertilizers as recommended in Agricultural Soil Suitability Report per 1,000 square feet.
E. Unless at ready required by the recommendations of the Agricultural Soil Suitability Report apply the following additional soil amendments:

1. Compost: 1 inch minimum depth
2. Calpril Lime: 12.0 pounds per 1,000 square feet

F. Incorporate remaining soil amendments into topsoil of lawn areas to a total depth of 4 inches.

G. Leveling Rolling: Drag with flexible tine harrow (or approved equipment, including hand rakes) to remove ridges and fill depressions, as required to meet finish grades. Roll areas (minimum roller weight 10 pounds per square inch) in two opposing directions.

H. Repeat rolling procedures and drag lightly to establish a smooth uniform compacted surface free of rocks and other extraneous matter. Provide compaction to 85 percent relative density.

I. Water lightly and allow planting mix to settle. Add additional material at mixture indicated in paragraph above to bring soil level to grades shown on the Drawings with allowance at pavement edges. Provide compaction to 85 percent relative density.

J. Meet lines, grades and elevations shown, after light rolling and natural settlement. Fine grade lawn areas to smooth even surface with loose, uniformly fine texture. Rake and drag lawn areas to remove ridges and fill depressions to obtain firmness and finish grades preparatory to receiving lawn planting.

K. Remove stones over 1/2-inch in any dimension and sticks, roots, rubbish and other extraneous matter.

L. Finish Grading: Grade lawn areas to smooth, even surface with a loose uniformly fine texture. Finish grade of soil shall be 1/2 inch below adjacent pavement. Limit preparation to areas which will be planted promptly after preparation.

M. Moisten prepared lawn areas before planting if soil is dry. Water thoroughly and allow surface moisture to dry before laying sod. Do not create a muddy soil condition.

N. Restore turf bed areas to specified condition if eroded or otherwise disturbed after fine grading and prior to placing sod.

3.5 SOIL PREPARATION FOR PLANTING PITS OF TREES

A. This article pertains to tree planting when occurring on an individual basis.

1. Backfill Mix: Prepare backfill mix and place in planting pits as specified.
2. Grade smooth to elevations shown.
3.6 SOIL PREPARATION FOR CRAPE MYRTLE TREES

A. This article pertains to the crape myrtle trees planted on an individual basis.

1. Over-excavate as necessary to place circle of 3 inch perforated drain tubing at bottom of planting pit and drain rock as shown on the Drawings. Make and test all tight line connections prior to any backfilling or soil placement.
2. Cover drain rock with geotextile fabric, lapping sheet or roll edges a minimum of 12 inch as necessary for complete coverage of drain rock layer.
3. Place prepared backfill material in planting pit as specified.
4. Grade smooth to elevations shown.

3.7 COIL PREPARATION UNDER EXISTING TREES

A. Remove vegetation not indicated to remain beneath canopy of existing trees. Take care not to disturb roots of existing trees.

B. Lightly rake areas and add amended topsoil to meet proposed grades.

3.8 FINE GRADING

A. Finish grade after full settlement including mulch, shall be 1 inch below tops of curbs, walks, or existing grades in shrub areas and 3/4 inch lower in lawn areas.

B. Slope all areas to prevent puddling and drain surface water toward catch basins, drains, curbs, or off-site as shown on Drawings.

C. Soil in all areas shall be thoroughly settled, with a smooth surface free of humps and hollows, and shall be firm enough to resist undesirable impressions when stepped upon.

D. Use levels, screens, drags, or any other equipment necessary to establish and verify grades and surfaces,

E. Finish grade lawn, grass and planting areas to smooth, even surface with loose, uniformly fine texture.

F. Roll, rake, and drag lawn areas, remove ridges and fill depressions with amended topsoil to obtain firmness and finish grades as indicated.

G. Notify Owner's Representative 36 hours in advance to review fine grading of lawn, grass and planting areas. Finish grades shall be prepared to the satisfaction of the Owner's Representative prior to planting.
3.9 CLEAN-UP

A. Clean up excess materials and debris from project site upon completion of work or sooner if directed by the Owner’s Representative.

B. Leave in neat and tidy condition daily.

3.10 DISPOSAL

A. Disposal: Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner’s property.

END OF SECTION 329113