MONTEREY COUNTY
RESOURCE MANAGEMENT AGENCY

PUBLIC WORKS - ARCHITECTURAL SERVICES

VOLUME THREE OF THREE

PROJECT MANUAL

NEW JUVENILE HALL
PROJECT NO. 8811
BID NO. 10560

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DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING

SECTION 230130.51 - HVAC AIR-DISTRIBUTION SYSTEM CLEANING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes cleaning HVAC air-distribution equipment, ducts, plenums, and system components.

1.2 DEFINITIONS

A. ASCS: Air systems cleaning specialist.

B. NADCA: National Air Duct Cleaners Association.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For an ASCS.

B. Strategies and procedures plan.

C. Cleanliness verification report.

1.4 QUALITY ASSURANCE

A. ASCS Qualifications: A certified member of NADCA.

1. Certification: Employ an ASCS certified by NADCA on a full-time basis.
2. Supervisor Qualifications: Certified as an ASCS by NADCA.

B. UL Compliance: Comply with UL 181 and UL 181A for fibrous-glass ducts.

C. Cleaning Conference: Conduct conference at Project site.

1. Review methods and procedures related to HVAC air-distribution system cleaning including, but not limited to, review of the cleaning strategies and procedures plan.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine HVAC air-distribution equipment, ducts, plenums, and system components to determine appropriate methods, tools, and equipment required for performance of the Work.

B. Perform "Project Evaluation and Recommendation" according to NADCA ACR 2006 (or most current edition).

C. Prepare written report listing conditions detrimental to performance of the Work.

D. Proceed with work only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare a written plan that includes strategies and step-by-step procedures. At a minimum, include the following:

1. Supervisor contact information.
2. Work schedule including location, times, and impact on occupied areas.
3. Methods and materials planned for each HVAC component type.
4. Required support from other trades.
5. Equipment and material storage requirements.
6. Exhaust equipment setup locations.

B. Use the existing service openings, as required for proper cleaning, at various points of the HVAC system for physical and mechanical entry and for inspection.

C. Comply with NADCA ACR 2006, "Guidelines for Constructing Service Openings in HVAC Systems" Section.

3.3 CLEANING

A. Comply with NADCA ACR 2006 (or most current edition).

B. Remove visible surface contaminants and deposits from within the HVAC system.

C. Systems and Components to Be Cleaned:

1. Air devices for supply and return air.
2. Air-terminal units.
3. Ductwork:

a. Supply-air ducts, including turning vanes and reheat coils, to the air-handling unit.
b. Return-air ducts to the air-handling unit.
c. Exhaust-air ducts.

4. Air-Handling Units:

    a. Interior surfaces of the unit casing.
    b. Coil surfaces compartment.
    c. Condensate drain pans.
    d. Fans, fan blades, and fan housings.

5. Filters and filter housings.

D. Collect debris removed during cleaning. Ensure that debris is not dispersed outside the HVAC system during the cleaning process.

E. Particulate Collection:

1. For particulate collection equipment, include adequate filtration to contain debris removed. Locate equipment downwind and away from all air intakes and other points of entry into the building.
2. HEPA filtration with 99.97 percent collection efficiency for particles sized 0.3 micrometer or larger shall be used where the particulate collection equipment is exhausting inside the building,

F. Control odors and mist vapors during the cleaning and restoration process.

G. Mark the position of manual volume dampers and air-directional mechanical devices inside the system prior to cleaning. Restore them to their marked position on completion of cleaning.

H. System components shall be cleaned so that all HVAC system components are visibly clean. On completion, all components must be returned to those settings recorded just prior to cleaning operations.

I. Clean all air-distribution devices, registers, grilles, and diffusers.

J. Clean visible surface contamination deposits according to NADCA ACR 2006 and the following:

1. Clean air-handling units, airstream surfaces, components, condensate collectors, and drains.
2. Ensure that a suitable operative drainage system is in place prior to beginning wash-down procedures.
3. Clean evaporator coils, reheat coils, and other airstream components.

K. Duct Systems:

1. Create service openings in the HVAC system as necessary to accommodate cleaning.
2. Mechanically clean duct systems specified to remove all visible contaminants so that the systems are capable of passing the HVAC System Cleanliness Tests (see NADCA ACR 2006).

L. Debris removed from the HVAC system shall be disposed of according to applicable Federal, state, and local requirements.

M. Mechanical Cleaning Methodology:

1. Source-Removal Cleaning Methods: The HVAC system shall be cleaned using source-removal mechanical cleaning methods designed to extract contaminants from within the HVAC system and to safely remove these contaminants from the facility. No cleaning method, or combination of methods, shall be used that could potentially damage components of the HVAC system or negatively alter the integrity of the system.

    a. Use continuously operating vacuum-collection devices to keep each section being cleaned under negative pressure.
    b. Cleaning methods that require mechanical agitation devices to dislodge debris that is adhered to interior surfaces of HVAC system components shall be equipped to safely remove these devices. Cleaning methods shall not damage the integrity of HVAC system components or damage porous surface materials such as duct and plenum liners.

2. Cleaning Mineral-Fiber Insulation Components:

    a. Fibrous-glass thermal or acoustical insulation elements present in equipment or ductwork shall be thoroughly cleaned with HEPA vacuuming equipment while the HVAC system is under constant negative pressure and shall not be permitted to get wet according to NADCA ACR 2006.
    b. Cleaning methods used shall not cause damage to fibrous-glass components and will render the system capable of passing the HVAC System Cleanliness Tests (see NADCA ACR 2006).
    c. Fibrous materials that become wet shall be discarded and replaced.

N. Coil Cleaning:

1. Measure static-pressure differential across each coil.
2. See NADCA ACR 2006, "Coil Surface Cleaning" Section. Type 1, or Type 1 and Type 2, cleaning methods shall be used to render the coil visibly clean and capable of passing Coil Cleaning Verification (see applicable NADCA ACR 2006).
3. Coil drain pans shall be subject to NADCA ACR 2006, "Non-Porous Surfaces Cleaning Verification." Ensure that condensate drain pans are operational.
4. Electric-resistance coils shall be de-energized, locked out, and tagged before cleaning.
5. Cleaning methods shall not cause any appreciable damage to, cause displacement of, inhibit heat transfer, or cause erosion of the coil surface or fins, and shall comply with coil manufacturer's written recommendations when available.
6. Rinse thoroughly with clean water to remove any latent residues.

O. Antimicrobial Agents and Coatings:

1. Apply antimicrobial agents and coatings if active fungal growth is reasonably suspected or where unacceptable levels of fungal contamination have been verified. Apply antimicrobial agents and coatings according to manufacturer's written recommendations and EPA registration listing after the removal of surface deposits and debris.
2. When used, antimicrobial treatments and coatings shall be applied after the system is rendered clean.
3. Apply antimicrobial agents and coatings directly onto surfaces of interior ductwork.

4. Sanitizing agent products shall be registered by the EPA as specifically intended for use in HVAC systems and ductwork.

3.4 CLEANLINESS VERIFICATION

A. Verify cleanliness according to NADCA ACR 2006, "Verification of HVAC System Cleanliness" Section.

B. Verify HVAC system cleanliness after mechanical cleaning and before applying any treatment or introducing any treatment-related substance to the HVAC system, including biocidal agents and coatings.

C. Perform visual inspection for cleanliness. If no contaminants are evident through visual inspection, the HVAC system shall be considered clean. If visible contaminants are evident through visual inspection, those portions of the system where contaminants are visible shall be re-cleaned and subjected to re-inspection for cleanliness.

D. Additional Verification:

1. Perform surface comparison testing or NADCA vacuum test.
2. Conduct NADCA vacuum gravimetric test analysis for nonporous surfaces.

E. Verification of Coil Cleaning:

1. Measure static-pressure differential across each coil.
2. Coil will be considered clean if cleaning restored the coil static-pressure differential within 10 percent of the differential measured when the coil was first installed.
3. Coil will be considered clean if the coil is free of foreign matter and chemical residue, based on a thorough visual inspection.

F. Prepare a written cleanliness verification report. At a minimum, include the following:

1. Written documentation of the success of the cleaning.
2. Site inspection reports, initialed by supervisor, including notation on areas of inspection, as verified through visual inspection.
3. Surface comparison test results if required.
4. Gravimetric analysis (nonporous surfaces only).
5. System areas found to be damaged.

G. Photographic Documentation: Comply with requirements in Section 013233 "Photographic Documentation."

3.5 RESTORATION

A. Restore and repair HVAC air-distribution equipment, ducts, plenums, and components according to NADCA ACR 2006, "Restoration and Repair of Mechanical Systems" Section.

B. Restore service openings capable of future reopening. Comply with requirements in Section 233113 "Metal Ducts." Include location of service openings in Project closeout report.

C. Replace fibrous-glass materials that cannot be restored by cleaning or resurfacing. Comply with requirements in Section 233113 "Metal Ducts".

D. Replace damaged insulation according to Section 230713 "Duct Insulation."

E. Ensure that closures do not hinder or alter airflow.

F. New closure materials, including insulation, shall match opened materials and shall have removable closure panels fitted with gaskets and fasteners.

END OF SECTION 230130.51

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.2 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

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

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined by NEMA and per ASHRAE Standard 90.1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

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

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.

2. Split phase.
3. Capacitor start, inductor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

SECTION 230514-VARIABLE FREQUENCY / SPEED CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish, test and install variable (speed) controllers (VFDs) where shown and scheduled on the Drawings and as specified in this Section.

B. The Electrical Contractor shall be responsible for power connections to the VFD and the controller motor.

C. The Control Subcontractor shall provide all control wiring and interlocks to the invertor.

1.2 QUALITY ASSURANCE

A. Comply with NFPA 70, "National Electrical Code."

B. NRTL Listing: Provide NRTL listed motors.

1. Term "Listed": As defined in "National Electrical Code," Article 100.
2. Listing Agency Qualifications: "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

C. Comply with NEMA MG 1, "Motors and Generators."

D. Comply with UL 1004, "Motors, Electric."

1.3 COMPATIBILITY

A. The drive shall be totally compatible with the type of motor and load it shall power and control. The supplier of the drive equipment shall coordinate and insure this compatibility. Refer to NEC Table 430-150 for minimum drive amp requirements for various motor HP ratings.

B. All VFDs furnished by the Contractor under this Section shall be of one brand (manufacturer) for both fan and pump applications. Mixing of brands shall not be allowed.

1.4 SUBMITTALS

A. General: Submit complete shop drawings including connection diagrams, control schematics, and operation and maintenance manual as follows:

1. Outline drawings showing dimensions, sizes, weights, component locations, etc.
2. Connection diagrams identifying line, load, and external control connection points. Terminal and conductor identification shall correspond to power and control schematics submitted under other sections.

3. Internal wiring diagrams showing internal components and associated interconnections. Drawings shall be sufficiently complete to allow the engineer to determine compliance with specifications.
4. Operation and Maintenance Manual shall include a complete technical description of operation of the unit, complete setup instructions, a troubleshooting guide, a complete parts list with number identifications, and a list of recommended spare parts.
5. Submit test as required by the start-up services section for review and approval.

PART 2 - PRODUCTS

2.1 VARIABLE FREQUENCY DRIVES

A. Approved Manufacturers:

1. ABB; Square-D
2. Cutler Hammer
3. Danfoss, Inc.
4. Toshiba
5. Yaskawa

B. Variable frequency drive (VFD) shall be suitable for control of standard NEMA Design B 3-phase induction motor.

2.2 VARIABLE FREQUENCY MOTOR CONTROLLER

A. Shall be either 6-step or PWM type and shall produce a 3-phase output capable of providing efficient operation of standard NEMA or IEC design AC induction motors.

1. The control shall consist of a power section made up of a fixed AC to DC converter, a fused filter, storage network, and an inverter, using either bipolar transistors or IGBTs in the power switching section.
2. Drives shall have a logic control section which is microprocessor based, using a 16-bit processor and LSI for minimum part count and maximum reliability. Adjustments shall be made via digital keypad rather than potentiometers.
3. The power section shall be isolated from the control section between the driver output of the control printed circuit card and the power switching devices.

B. The VFD drive shall be operable in two modes.

1. In the "HAND" mode, the unit shall start and run at a speed as set on the manual potentiometer.
2. In the "AUTO" mode, the unit shall start in response to a contact closure and run at a speed established by an analog control signal.
3. Opening of remote safety loop shall disable operation in any mode.

C. Specifications:

1. Input power 3-phase, 60 Hz, 460 VAC.

   a. Nominal input voltage +/- 10%
   b. +/- 5% input frequency stability

2. Provide AC line (input) rectors with 3 percent impedance, mounted and wired in VFD cabinet for both 6-step and PWM drives.
3. Minimum continuous VFD amps and minimum line rector inductance shall be as follows:
4. Comply to FCC Subpart J of Part 15 for Class A computing device from 7 MHZ to 30 MHZ for conduction limit without external modification.
5. Output Power: 3-phase, 1.2 to 80 Hz with variable voltage to give proper and efficient operation of variable torque load.
6. Overload capacity of 125 percent for 1 minute.
7. Input power factor, 95 percent minimum at all speeds and loads.
8. Provide gasketed NEMA 1 enclosure of 14 gage steel (minimum) with single door, heavy continuous hinge, and padlock hasp. VFD display and keypad shall be accessible with door open or closed.

D. Minimum Requirements for Control Operation and Service:

1. Door-interlocked, fused disconnect switch, heavy duty type with provision for padlocking with up to three padlocks. Interlock handle shall be of heavy cast metal (not plastic) construction. Fuses shall be 200,000 AIC, Class R, dual element type.
2. Isolated 115 VAC control transformer with fused primary and secondary per 2005 NEC (or latest edition) and with 120V, 10-amp relay for safeties and for remote start contacts.
3. Digital annunciated fault and limit functions individually annunciated for:

   a. Thermal overload relay trip
   b. Microprocessor self-check function
   c. Output overcurrent trip
   d. DC bus overvoltage trip
   e. Inverse time overload trip
   f. Heatsink overtemperature trip
   g. DC bus fuse open
   h. DC bus overvoltage (regen. limit)
   i. Output ground fault
   j. Undervoltage/phase loss

   Note: The VFD shall retain at least the last four faults for display, in order of occurrence.

4. Lamp annunciated functions for:

   a. Inverter ready light
   b. Inverter run light
   c. Inverter safeties okay light (green)
   d. Power line on light
   e. Inverter stop light

E. Minimum Required Standard Features:

1. Door mounted components:

    a. Inverter run indication
    b. Remote safety indication
    c. Digital speed (frequency or percent speed) and motor ammeter
    d. Manual speed potentiometer
    e. Hand/Off/Auto selector switch (heavy duty oil-tight type)
    f. Reset push-button for fault and enable
    g. Annunciation as in Paragraph D.

2. DC bus charged indicator.
3. Adjustable current limit circuit active to prevent nuisance tripping during acceleration or run conditions.
4. Regeneration limit circuit active to prevent nuisance OV tripping during deceleration.
5. Minimum and maximum speed set, separate and non-interactive. Operation higher than maximum speed setting shall not be possible, even if remote signal exceeds nominal maximum (i.e. 25 ma on a 20 ma circuit).
6. Power loss restart selectable for Auto Restart in auto mode only.
7. Critical frequency lockout for up to 3 points, available from 10 to 100 percent speed with an adjustable bandwidth.
8. Only non-filament type indicating lights may be used.
9. Control shall survive without component failure, and annunciate output phase-to-phase ground faults.
10. Control shall have the following isolated instrument control signal follower: 4 to 20 madc or 0 to 10 vdc.
11. Volts per hertz ratio shall be automatic, tracking motor load requirements to achieve most efficient operation; potentiometer adjustments not allowed. Control shall have available 15 selectable volts per hertz patterns.
12. To reduce possible acoustical noise and electrical interference, PWM type drive control must have an automatically variable carrier frequency of at least 380 to 2500 hertz. Carrier frequency must be field adjustable. There shall be no sudden frequency shifts which cause acoustical noise increases during changes in frequency output to motor.
13. Control must be capable of starting into a spinning motor. Must also be capable of stopping a motor rotating in the reverse direction and then accelerating that motor in the proper direction.
14. A three pole thermal motor overload relay with Class 10 heaters connected to shut down the motor on trip-out, in addition to VFD time-overcurrent motor protection. VFD electronic overload shall reduce amp level at speeds below 50 percent to compensate for reduced motor capacity at low speeds.
15. All components must be supplied in an integral enclosure with a single door; separate enclosures are not allowed.
16. Provide auxiliary contacts for VFD run and VFD fault, wired to terminals for customer use.
17. Control shall be "ride-through" momentary power losses of 2 seconds or less.
18. All controls under 150 horsepower will require ETL or U/L nationally recognized testing laboratory approval.
19. Provide manual/automatic bypass for each drive.

    a. Provide bypass with soft-start function on VFDs.

20. Provide line reactors, harmonic filters or any other devices necessary to maintain 5 percent or less voltage and current distortion at the VFD mounted disconnect.
21. Drive and bypass U.L. labeled.
22. Drive test capabilities during bypass operation.
23. Provide factory mounted disconnect switch with minimum 100,000 amp short circuit withstand rating.
24. VFD shall be limited to 5 percent voltage and current distortion at the VFD mounted disconnect.
25. The VFD is to be provided with transitional or other devices necessary to complete bi-directional communication with temperature control system. All data at VFD control panel shall be available at DDC-front end computer. Refer to Division 23 Section "Instrumentation and Control for HVAC."

2.3 QUALITY ASSURANCE TESTS

A. The following quality assurance factory tests and procedures shall be conducted on the drive and its components prior to shipment.

1. SCRs and diodes shall be tested to ensure correct function and highest reliability.

   a. Every controller will be functionally tested under designed motor load for eight hours to ensure that if the drive is started up according to the instruction manual provided, that unit will run properly.
   b. The VFD manufacturer shall provide certification that the tests have been completed.

2. Each VFD shall be tested for voltage and current distortion by a factory qualified or independent qualified source. The voltage and current distortion shall be 5 percent or less when tested at the VFD mounted disconnect through the operating range of the VFD.

   a. The following reading shall be included in the test reports for each VFD:

      1) input KVA
      2) total power factor
      3) 3-phase input voltage
      4) 3-phase current
      5) 3-phase input voltage total harmonic distortion (THD)
      6) 3-phase input total demand distortion (TDD)

   b. For review and approval, a report shall be submitted to the Engineer/Architect indicating the voltage and current distortion for each drive. If any VFD does not meet the 5 percent voltage and current distortion performance requirements, the Contractor is responsible for upgrading the VFD to meet specified requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: The drives shall be installed, tested, and calibrated in accordance with Division 23 Section "Basic Mechanical Requirements," and manufacturer's recommendations.

3.2 STARTUP SERVICES

A. The Variable Frequency Drive (VFD) manufacturer shall provide, as a minimum, the following services:

1. Factory coordinated startup service for each and every drive with written deficiency reports.
2. Training of Owner's personnel in basic operation and troubleshooting. Training shall be on-site, shall be a minimum of three days' duration, and shall be performed in addition to startup of system.
3. Each VFD manufacturer shall have a local representative specifically trained in troubleshooting and service and repair of its VFD. A statement of the length and extent of experience of the local service organization shall be included with the submittals.

END OF SECTION 230514

SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.

1.2 ACTION 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.

D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Smith, Jay R. Mfg. Co.
2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.
3. Or approved equal.

B. 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, provide products 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 equal.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM-rubber 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: Stainless steel of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Presealed Systems.
2. Or approved equal.

B. 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

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement 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 specified in Section 079200 "Joint Sealants."

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 specified in Section 078413 "Penetration Firestopping."

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 specified in Section 076200 "Sheet Metal Flashing and Trim."
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 specified in Section 078413 "Penetration Firestopping."

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: Cast-iron wall sleeves or galvanized-steel wall sleeves or galvanized-steel-pipe sleeves.
   b. Piping NPS 6 and Larger: Cast-iron wall sleeves or galvanized-steel wall sleeves or galvanized-steel-pipe sleeves.

2. Exterior Concrete Walls below Grade:

   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system or 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: Cast-iron wall sleeves with sleeve-seal system or 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: Cast-iron wall sleeves with sleeve-seal system or 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.

b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system or 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.

4. Concrete Slabs above Grade:

a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves or stack-sleeve fittings or sleeve-seal fittings.
b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves or stack-sleeve fittings.

5. Interior Partitions:

a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
b. Piping NPS 6 and Larger: Galvanized-steel-sheet sleeves.

END OF SECTION 230517

SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

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

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

2.2 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons:

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

b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
c. Insulated Piping: One-piece, stamped-steel type.
d. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
e. Bare Piping in Equipment Rooms: One-piece, cast-brass type with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Piping: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 230518

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Fastener systems.

B. Related Sections:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 230548 "Vibration and Seismic Controls for HVAC" for vibration isolation devices.
3. Section 233113 "Metal Ducts" for duct hangers and supports.

1.2 DEFINITIONS

A. MSS: Manufacturers Standardization Society of Valve and Fittings Industry Inc.

1.3 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 HVAC 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 equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
2. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.4 ACTION 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.

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.

1.5 INFORMATIONAL SUBMITTALS

A. 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. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel.

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 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Allied Tube & Conduit.
    b. Cooper B-Line, Inc.
    c. Flex-Strut Inc.
    d. GS Metals Corp.
    e. Thomas & Betts Corporation.
    f. Unistrut Corporation; Tyco International, Ltd.
    g. Wesanco, Inc.
    h. Or approved equal.

2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
3. Standard: MFMA-4.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel.
7. Non-Metallic Coating: Plastic jacket or liner.

2.4 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Carpenter & Paterson, Inc.
2. Clement Support Services.
3. ERICO International Corporation.
4. National Pipe Hanger 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.
10. Or approved equal.

B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig] or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig, ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-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.

2.5 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 stainless-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.

2.6 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.7 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, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. 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.

B. 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.

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

G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

H. 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.

I. 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.

5. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 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/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.

3.3 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.

3.4 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 Section 099113 "Exterior Painting," Section 099123 "Interior Painting" and Section 099600 "High Performance Coatings."

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.5 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 pipe hangers and supports, metal trapeze pipe hangers and metal framing systems and attachments for general service applications.

F. Use copper-plated pipe hangers and copper or stainless-steel 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 noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. 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.

J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

K. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

END OF SECTION 230529

SECTION 230548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Housed-spring isolators.
5. Restrained-spring isolators.
6. Housed-restrained-spring isolators.
7. Elastomeric hangers.
8. Spring hangers.
9. Snubbers.
10. Mechanical anchor bolts.

B. Related Requirements:

1. Section 220548 "Vibration and Seismic Controls for Plumbing" for devices for plumbing equipment and systems.

1.2 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.3 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: 85 mph.
2. Building Classification Category: C.
3. Minimum 10 lb/sq. ft. multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the CBC: **D**.

2. Assigned Seismic Use Group or Building Category as Defined in the CBC: **III**.

    a. Component Importance Factor: 1.0
    b. Component Response Modification Factor: (Varies by system type).

        1) Piping Systems with Joints Made by Welding or Brazing: 12.0
        2) Piping Systems with Joints Made by Threading or grooved Couplings: 6.0
        3) Piping Systems with Low-Deformability Materials (Cast Iron): 3.0

    c. Component Amplification Factor: 2.5

3. Design Spectral Response Acceleration at Short Periods (0.2 Second): 0.557
4. Design Spectral Response Acceleration at 1-Second Period: 0.334

1.4 ACTION 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 vibration isolation device and seismic-restraint component required.

    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 OSHPD, or an agency acceptable to authorities having jurisdiction.
    b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. 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.

C. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

1. Include design calculations and details for selecting vibration isolators, seismic restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation, and seismic and wind forces required to select vibration isolators and seismic and wind 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.

~~3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.~~

~~4.~~3. Seismic- and Wind-Restraint Details:

a. Design Analysis: To support selection and arrangement of seismic and wind 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 OSHPD, or an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For all vibration isolation devices and seismic to include in operation and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 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 and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Manufacturers: Subject to compliance with requirements, provide products 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 equal.

2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties.
5. Surface Pattern: Waffle pattern.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.
8. Sandwich-Core Material: Resilient and elastomeric.

    a. Surface Pattern: Waffle pattern.
    b. Infused nonwoven cotton or synthetic fibers.

2.2 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:

1. Manufacturers: Subject to compliance with requirements, provide products 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 equal.

2. Mounting Plates:

a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.3 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:

1. Manufacturers: Subject to compliance with requirements, provide products 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 equal.

2. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

a. Housing: Cast ductile iron or welded steel.

b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:.

1. Manufacturers: Subject to compliance with requirements, provide products 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 equal.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

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. Top housing with threaded mounting holes and internal leveling device.

2.5 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:

1. Manufacturers: Subject to compliance with requirements, provide products 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 equal.

~~2. Housing: Steel housing with vertical limit stops to prevent spring extension due to weight being removed.~~

~~a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.~~
~~b. Top plate with threaded mounting holes.~~
~~c. Internal leveling bolt that acts as blocking during installation.~~

~~3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.~~
~~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.~~
~~6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.~~
~~7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.~~

~~2.6~~2.2 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:

1. Manufacturers: Subject to compliance with requirements, provide products 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 equal.

2. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with 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.

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.

~~2.7 PIPE RISER RESILIENT SUPPORT~~

~~A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch-thick neoprene.~~

~~1. Vertical Limit Stops: Steel and neoprene vertical limit stops arranged to prevent vertical travel in both directions.~~
~~2. Maximum Load Per Support: 500 psigon isolation material providing equal isolation in all directions.~~

~~2.8 RESILIENT PIPE GUIDES~~

~~A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch-thick neoprene.~~

~~1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.~~

~~2.9 ELASTOMERIC HANGERS~~

~~A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:~~

~~1. Manufacturers: Subject to compliance with requirements, provide products 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 Mountings & Controls, Inc.~~
~~h. Or approved equal.~~

~~2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.~~
~~3. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.~~

~~2.10~~2.3 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Ace Mountings Co., Inc.
b. California Dynamics Corporation.
c. Kinetics Noise Control, Inc.
d. Mason Industries, Inc.
e. Vibration Eliminator Co., Inc.
f. Vibration Isolation.
g. Vibration Mountings & Controls, Inc.
h. Or approved equal.

2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
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.
7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
9. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

~~2.11~~2.4 SNUBBERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Kinetics Noise Control, Inc.
2. Mason Industries, Inc.
3. Vibration Mountings & Controls, Inc.
4. Or approved equal.

B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch air gap, and minimum 1/4-inch-thick resilient cushion.

~~2.12~~2.5 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Amber/Booth Company, Inc.

2. California Dynamics Corporation.
3. Cooper B-Line, Inc.; a division of Cooper Industries.
4. Hilti, Inc.
5. Kinetics Noise Control.
6. Loos & Co.; Cableware Division.
7. Mason Industries.
8. TOLCO Incorporated; a brand of NIBCO INC.
9. Unistrut; Tyco International, Ltd.
10. Or approved equal.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES OSHPD 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. Description: MFMA-4, shop- or field-fabricated bracing 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; rated in tension, compression, and torsion forces.

D. Restraint Cables: ASTM A 603 galvanized or ASTM A 492 stainless-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; 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 to hanger rod.

F. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

G. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

H. 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 used.

I. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

J. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in 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.

2.13 RESTRAINED VIBRATION ISOLATION EQUIPMENT BASES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. California Dynamics Corporation.
2. Kinetics Noise Control.
3. Mason Industries, Inc.
4. Vibration Eliminator Co., Inc.
5. Vibration Isolation.
6. Vibration Mountings & Controls, Inc.
7. Or approved equal.

B. Steel Rails: Factory-fabricated, welded, structural-steel rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide rails.

a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Rails shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

D. Concrete Inertia Base: Factory-fabricated or field-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails. Designed for seismic force resistance.

a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

4. Fabrication: Fabricate steel templates to hold equipment anchor bolt sleeves and anchors in place during placement of concrete. Obtain anchor bolt templates from supported equipment manufacturer.

2.14 RESTRAINED ISOLATION ROOF CURB RAILS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ace Mountings Co., Inc.
2. California Dynamics Corporation.
3. Kinetics Noise Control.
4. Mason Industries, Inc.
5. Thybar Corporation.
6. Or approved equal.

B. Description: Factory assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind forces.

C. Upper Frame: The upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic and wind forces.

D. Lower Support Assembly: The lower support assembly shall be formed sheet metal section containing adjustable and removable steel springs that support the upper frame. The lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches of rigid, glass fiber insulation on inside of assembly. Adjustable, restrained spring isolators shall be mounted on elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.

E. Snubber Bushings: All directional, elastomeric snubber bushings at least 1/4 inch thick.

F. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic- and wind-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES, or OSHPD, 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 due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND 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 specified in Section 033000 "Cast-in-Place Concrete," or Section 033053 "Miscellaneous Cast-in-Place Concrete."

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

D. Equipment Restraints:

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
3. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES, or OSHPD, or an agency acceptable to authorities having jurisdiction that provides required submittals for component.

E. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.

F. Install cables so they do not bend across edges of adjacent equipment or building structure.

G. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES, or OSHPD, or an agency acceptable to authorities having jurisdiction that provides required submittals for component.

H. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

I. 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.

J. 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.

K. 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 piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 232113 "Hydronic Piping" for piping flexible connections.

3.5 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. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. Test and adjust restrained-air-spring isolator controls and safeties.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after piping system 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.

3.7 VIBRATION ISOLATION EQUIPMENT BASES INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete," or Section 033053 "Miscellaneous Cast-in-Place Concrete."

3.8 APPLICATIONS

HVAC VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE SCHEDULE *

A. Suspended Equipment:

1. Equipment Location: Refer to plans.
2. Isolator Type: Spring hangers.
3. Minimum Deflection: ~~2~~1.0 inches.

~~B. Base-Mounted Air Handling Units:~~

~~1. Equipment Location: Basement Mechanical Room.~~
~~2. Pads:~~

~~a. Material: Rubber Waffle.~~
~~b. Thickness: 3/4-inch thick.~~
~~c. Number of Pads: 1.~~

~~3. Deflection Rating: 30 Durometer.~~

~~C. Rooftop Curb-Mounted Equipment:~~

~~1. Equipment Location: Building roof.~~
~~2. Isolator Type: Restrained vibration isolation roof curb rail.~~
~~3. Minimum Deflection: 3.0 inches.~~

~~D.~~B. Suspended FCU - Split-System Units - All**

1. Equipment Location: Ceiling- / wall-mounted IU units.
2. Isolator Type: Rubber hanger / elastomeric hanger.
3. Minimum Deflection: 1~~2~~ inch.

~~E.~~C. Base Mounted CU - Split-System Units - All**

1. Equipment Location: At Grade.
2. Pads:

   a. Material: Rubber Waffle.
   b. Thickness: 3/4-inch thick.
   c. Number of Pads: 1.

* Earthquake Seismic Restraint: Where required by SMACNA and California Codes, install earthquake-restrained spring isolator units. See plans and details for seismic restraint required locations.

** All vibration isolated equipment will have flexible connections including ducts, electrical, and plumbing (Mason MFDEJ/SFDEJ twin sphere for water and Mason CPSB braided copper for OU refrigerant line). Use rubber plumbing isolators for refrigerant line supports between OU and IU (Hubbard Holdrite Silencer).

END OF SECTION 230548

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.
5. Valve tags.
6. Warning tags.

1.2 ACTION 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.

1.3 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.
4. Fasteners: Stainless-steel rivets or self-tapping screws.
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 thick, and having predrilled holes for attachment hardware.
2. Letter Color: Red.
3. Background Color: White.
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. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full 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 incheshigh.

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. Letter Color: White.

C. Background Color: Blue.

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. 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 incheshigh.

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: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Yellow background with black lettering.

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. Piping Color-Coding: Painting of piping is specified in Division 09 Sections on interior painting and exterior painting.

B. 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.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Pipe Label Color Schedule:

1. Refrigerant Piping:

a. Background Color: Black.
b. Letter Color: White.

2. Condensate Drain Piping:

a. Background Color: White.
b. Letter Color: Black.

3.4 DUCT LABEL INSTALLATION

A. Install plastic-laminated, self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.
3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
4. 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:
   a. Refrigerant: 1-1/2 inches, round.
   b. Gas: 1-1/2 inches, round.

2. Valve-Tag Color:
   a. Refrigerant: Natural.
   b. Gas: Natural.

3. Letter Color:
   a. Refrigerant: White.
   b. Gas: White.

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Balancing Air Systems:

a. Constant-volume air systems.
b. Variable-air-volume systems.

2. Balancing Hydronic Piping Systems:

a. Constant-flow hydronic systems.
b. Variable-flow hydronic systems.
c. Primary-secondary hydronic systems.

1.2 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An entity engaged to perform TAB Work.

1.3 ACTION SUBMITTALS

A. LEED Submittals:

1. Air-Balance Report for Prerequisite IEQ 1: Documentation of work performed for ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
2. TAB Report for Prerequisite EA 2: Documentation of work performed for ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 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.

B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 60 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" 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 AABC or NEBB.

1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC or NEBB.
2. TAB Technician: Employee of the TAB contractor and who is certified by AABC or NEBB as a TAB technician.

B. TAB Conference: Meet with Architect, Owner, Construction Manager, and Commissioning Authority on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide seven days' advance notice of scheduled meeting time and location.

1. Agenda Items:

a. The Contract Documents examination report.
b. The TAB plan.
c. Coordination and cooperation of trades and subcontractors.
d. Coordination of documentation and communication flow.

C. 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.

D. TAB Report Forms: Use standard TAB contractor's forms approved by Architect, Owner, Construction Manager, and Commissioning Authority.

E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

F. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

G. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.6 PROJECT CONDITIONS

A. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 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 2 - PRODUCTS (Not Applicable)

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 ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Section 233113 "Metal Ducts" and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. 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.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. 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.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. 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 AABC's "National Standards for Total System Balance," ASHRAE 111, NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.

1. Comply with requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

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, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

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 in Section 233113 "Metal Ducts."

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 Architect, Owner, Construction Manager and Commissioning Authority 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.

C. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Balance variable-air-volume systems the same as described for constant-volume air systems.
2. Set terminal units and supply fan at full-airflow condition.
3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
4. Readjust fan airflow for final maximum readings.
5. Measure operating static pressure at the sensor that controls the supply fan if one is installed, and verify operation of the static-pressure controller.
6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
7. 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 the outlets balanced for maximum airflow.

8. Measure 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.

D. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
3. Set terminal units at full-airflow condition.
4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
5. Adjust terminal units for minimum airflow.
6. Measure static pressure at the sensor.
7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

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 CONSTANT-FLOW HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

    a. If impeller sizes must be adjusted to achieve pump performance, obtain approval from Architect, Owner, Construction Manager and Commissioning Authority and comply with requirements in Section 232123 "Hydronic Pumps."

2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.

    a. Monitor motor performance during procedures and do not operate motors in overload conditions.

3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
4. Report flow rates that are not within plus or minus 10 percent of design.

B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.

C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.

D. Set calibrated balancing valves, if installed, at calculated presettings.

E. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:

1. Determine the balancing station with the highest percentage over indicated flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
3. Record settings and mark balancing devices.

H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

I. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.

J. Check settings and operation of each safety valve. Record settings.

3.9 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.

3.10 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first and then balance the secondary circuits.

3.11 PROCEDURES FOR HEAT EXCHANGERS

A. Measure water flow through all circuits.

B. Adjust water flow to within specified tolerances.

C. Measure inlet and outlet water temperatures.

D. Measure inlet steam pressure.

E. Check settings and operation of safety and relief valves. Record settings.

3.12 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.
2. Motor horsepower rating.
3. Motor rpm.
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.

3.13 PROCEDURES FOR CHILLERS

A. Balance water flow through each evaporator and condenser to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:

1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
2. For water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
4. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.
5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
6. Capacity: Calculate in tons of cooling.

7. For air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.14 PROCEDURES FOR COOLING TOWERS

A. Shut off makeup water for the duration of the test, and verify that makeup and blowdown systems are fully operational after tests and before leaving the equipment. Perform the following tests and record the results:

1. Measure condenser-water flow to each cell of the cooling tower.
2. Measure entering- and leaving-water temperatures.
3. Measure wet- and dry-bulb temperatures of entering air.
4. Measure wet- and dry-bulb temperatures of leaving air.
5. Measure condenser-water flow rate recirculating through the cooling tower.
6. Measure cooling-tower spray pump discharge pressure.
7. Adjust water level and feed rate of makeup water system.
8. Measure flow through bypass.

3.15 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record compressor data.

3.16 PROCEDURES FOR BOILERS

A. Hydronic Boilers: Measure and record entering- and leaving-water temperatures and water flow.

3.17 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 10 percent or minus 5 percent.
2. Air Outlets and Inlets: Plus 10 percent or minus 5 percent.
3. Heating-Water Flow Rate: Plus 10 percent or minus 5 percent.
4. Cooling-Water Flow Rate: Plus 10 percent or minus 5 percent.

3.18 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.

B. Status Reports: Prepare biweekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.19 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. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
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.
6. Balancing stations.
7. Position of balancing devices.

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. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and unit size.

e. Manufacturer's serial number.
f. Fuel type in input data.
g. Output capacity in Btu/h.
h. Ignition type.
i. Burner-control types.
j. Motor horsepower and rpm.
k. Motor volts, phase, and hertz.
l. Motor full-load amperage and service factor.
m. Sheave make, size in inches, and bore.
n. Center-to-center dimensions of sheave, and amount of adjustments in inches.

2. Test Data (Indicated and Actual Values):

a. Total air flow rate in cfm.
b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Low-fire fuel input in Btu/h.
i. High-fire fuel input in Btu/h.
j. Manifold pressure in psig.
k. High-temperature-limit setting in deg F.
l. Operating set point in Btu/h.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h.

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.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.20 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 Architect, Owner, Construction Manager, and Commissioning Authority.
2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Architect, Owner, Construction Manager, and Commissioning Authority.
3. Architect, Owner, Construction Manager, and Commissioning Authority 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 Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.

3.21 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 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed supply / return located in unconditioned space.
4. Indoor, exposed supply / return located in unconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

B. Related Sections:

1. Section 230716 "HVAC Equipment Insulation."
2. Section 230719 "HVAC Piping Insulation."
3. Section 233113 "Metal Ducts" for duct liners.

1.2 ACTION 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. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.

D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:

1. Sheet Form Insulation Materials: 12 inches square.

2. Sheet Jacket Materials: 12 inches square.
3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. 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.

C. 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. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing 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 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.

C. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.

1. Ductwork Mockups:

    a. One 10-foot section each of rectangular and round straight duct.
    b. One each of a 90-degree mitered round and rectangular elbow, and one each of a 90-degree radius round and rectangular elbow.
    c. One rectangular branch takeoff and one round branch takeoff from a rectangular duct. One round tee fitting.
    d. One rectangular and round transition fitting.
    e. Four support hangers for round and rectangular ductwork.
    f. Each type of damper and specialty.

2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.

3. Notify Architect seven days in advance of dates and times when mockups will be constructed.
4. Obtain Architect's approval of mockups before starting insulation application.
5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
7. Demolish and remove mockups when directed.

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 in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork 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 "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation 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. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Aeroflex USA, Inc.; Aerocel.
b. Armacell LLC; AP Armaflex.
c. K-Flex USA; Insul-Sheet, K-Flex Gray Duct Liner, and K-FLEX LS.
d. Or approved equal.

G. 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 III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:

a. CertainTeed Corp.; SoftTouch Duct Wrap.
b. Johns Manville; Microlite.
c. Knauf Insulation; Friendly Feel Duct Wrap.
d. Manson Insulation Inc.; Alley Wrap.
e. Owens Corning; SOFTR All-Service Duct Wrap.
f. Or approved equal.

H. 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 FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of 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 equal.

I. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ or FSK jacket 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 one of 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 equal.

2.2 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F. Comply with ASTM C 656, Type II, Grade 6. Tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Johns Manville; Super Firetemp M.
    b. Or approved equal.

B. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. CertainTeed Corp.; FlameChek.
    b. Johns Manville; Firetemp Wrap.
    c. Nelson Fire Stop Products; Nelson FSB Flameshield Blanket.
    d. Thermal Ceramics; FireMaster Duct Wrap.
    e. 3M; Fire Barrier Wrap Products.
    f. Unifrax Corporation; FyreWrap.
    g. Or approved equal.

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 and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Aeroflex USA, Inc.; Aeroseal.
    b. Armacell LLC; Armaflex 520 Adhesive.

c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.K-Flex USA; R-373 Contact Adhesive.
d. Or approved equal.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive 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."

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.Eagle Bridges - Marathon Industries; 225.
b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.Mon-Eco Industries, Inc.; 22-25.
c. Or approved equal.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive 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."

D. ASJ Adhesive, and FSK Jacket 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 one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
b. Eagle Bridges - Marathon Industries; 225.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.Mon-Eco Industries, Inc.; 22-25.
d. Or approved equal.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive 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."

E. 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.
b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
c. P.I.C. Plastics, Inc.; Welding Adhesive.

d. Speedline Corporation; Polyco VP Adhesive.
e. Or approved equal.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive 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 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
b. Vimasco Corporation; 749.
c. Or approved equal.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. 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:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
b. Eagle Bridges - Marathon Industries; 501.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-35.
d. Mon-Eco Industries, Inc.; 55-10.
e. Or approved equal.

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.
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

D. 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:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
    b. Eagle Bridges - Marathon Industries; 570.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.
    d. Or approved equal.

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.
5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
    b. Eagle Bridges - Marathon Industries; 550.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
    d. Mon-Eco Industries, Inc.; 55-50.
    e. Vimasco Corporation; WC-1/WC-5.
    f. Or approved equal.

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

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. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, provide one of the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
    b. Vimasco Corporation; 713 and 714.
    c. Or approved equal.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
4. Service Temperature Range: 0 to plus 180 deg F.
5. Color: White.

2.6 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.Eagle Bridges - Marathon Industries; 405.
b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
c. Mon-Eco Industries, Inc.; 44-05.
d. Or approved equal.

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. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants 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. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
b. Or approved equal.

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: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants 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 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.

3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering ducts.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Chil-Glas No. 5.
b. Or approved equal.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for ducts.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Mast-A-Fab.
b. Vimasco Corporation; Elastafab 894.
c. Or approved equal.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

1. Products: Subject to compliance with requirements, provide one of the following:

a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.
b. Or approved equal.

2.10 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. 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.
b. P.I.C. Plastics, Inc.; FG Series.
c. Proto Corporation; LoSmoke.

d. Speedline Corporation; SmokeSafe.
e. Or approved equal.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: Color-code jackets based on system. Color as selected by Architect.

D. Metal Jacket:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
c. RPR Products, Inc.; Insul-Mate.
d. Or approved equal.

2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

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: 1-mil-thick, heat-bonded polyethylene and kraft paper or 3-mil-thick, heat-bonded polyethylene and kraft paper.
d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper or 2.5-mil-thick polysurlyn.

3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

a. Sheet and roll stock ready for shop or field sizing.
b. Material, finish, and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper or 3-mil-thick, heat-bonded polyethylene and kraft paper.
d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper or 2.5-mil-thick polysurlyn.

E. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white stucco-embossed aluminum-foil facing.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Polyguard Products, Inc.; Alumaguard 60.
b. Or approved equal.

2.11 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 equal.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
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. FSK Tape: Foil-face, 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; 491 AWF FSK.
    b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
    c. Compac Corporation; 110 and 111.
    d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
    e. Or approved equal.

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. 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 equal.

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

D. 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 equal.

2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.12 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 equal.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch or 3/4 inch wide with wing seal or closed seal.
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch or 3/4 inch wide with wing seal or closed seal.
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-or 0.135-inch-diameter shank, length to suit depth of insulation indicated.

    a. Products: Subject to compliance with requirements, provide one of the following:

        1) AGM Industries, Inc.; CWP-1.
        2) GEMCO; CD.
        3) Midwest Fasteners, Inc.; CD.
        4) Nelson Stud Welding; TPA, TPC, and TPS.
        5) Or approved equal.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-or 0.135-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

    a. Products: Subject to compliance with requirements, provide one of the following:

1) AGM Industries, Inc.; CHP-1.
2) GEMCO; Cupped Head Weld Pin.
3) Midwest Fasteners, Inc.; Cupped Head.
4) Nelson Stud Welding; CHP.
5) Or approved equal.

3. 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 one of the following:

      1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.
      2) GEMCO; Perforated Base.
      3) Midwest Fasteners, Inc.; Spindle.
      4) Or approved equal.

   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.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened 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 one of the following:

      1) GEMCO; Nylon Hangers.
      2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.
      3) Or approved equal.

   b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
   c. Spindle: Nylon, 0.106-inch-diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
   d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-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 one of the following:

      1) AGM Industries, Inc.; Tactoo Self-Adhering Insul-Hangers.
      2) GEMCO; Peel & Press.

3) Midwest Fasteners, Inc.; Self Stick.
4) Or approved equal.

b. Baseplate: 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-backed base with a peel-off protective cover.

6. 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 one of 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 equal.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

2.13 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. 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.

C. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316.

PART 3 - EXECUTION

3.1 EXAMINATION

A. 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.

B. 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.

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 ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct 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. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. 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.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. 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. 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, 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 duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. 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.

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 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.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: 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 in Section 078413 "Penetration Firestopping"irestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:

1. Duct: 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. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 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.

3.6 INSTALLATION OF MINERAL-FIBER INSULATION

A. 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 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 one edge and one 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 two 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.

B. 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 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 one edge and one 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 two 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.

3.7 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, install with longitudinal seams along top and bottom of tanks and vessels. 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.

3.8 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. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."

3.9 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

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.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

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 Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.10 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 ductwork, randomly selected by Architect, 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.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.11 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 unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

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.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

3.12 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, round and flat-oval, supply-air duct insulation shall be one of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.
2. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

B. Concealed, round and flat-oval, return-air duct insulation shall be one of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.
2. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

C. Concealed, rectangular, supply-air duct insulation shall be one of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.
2. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

D. Concealed, rectangular, return-air duct insulation shall be one of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.
2. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

E. Concealed, rectangular, outdoor-air duct insulation shall be one of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.
2. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

F. Concealed, rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be one of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.
2. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

G. Exposed, round and flat-oval, supply-air duct insulation shall be one of the following:

1. Exposed supply ductwork in conditioned areas shall be provided with internal duct liner of sufficient thickness to meet R-2.1 rating.
2. Exposed supply ductwork in unconditioned areas (mechanical rooms, garage, etc.) shall be provided with internal duct liner of sufficient thickness to provide R-4.2 rating.
3. Note: Ductwork designated to be double wall with perforated liner does not require exterior insulation as long as listed R-values are not by double wall duct insulation values.

H. Exposed, round and flat-oval, return-air duct insulation shall be one of the following:

1. Exposed return ductwork in conditioned areas does not require insulation.
2. Exposed return ductwork in unconditioned areas (mechanical rooms, garage, etc.) shall be provided with internal duct liner of sufficient thickness to provide R-4.2 rating.
3. Note: Ductwork designated to be double wall with perforated liner does not require exterior insulation as long as listed R-values are not by double wall duct insulation values.

I. Exposed, rectangular, supply-air duct insulation shall be one of the following:

1. Exposed supply ductwork in conditioned areas shall be provided with internal duct liner of sufficient thickness to meet R-2.1 rating.
2. Exposed supply ductwork in unconditioned areas (mechanical rooms, garage, etc.) shall be provided with internal duct liner of sufficient thickness to provide R-4.2 rating.
3. Note: Ductwork designated to be double wall with perforated liner does not require exterior insulation as long as listed R-values are not by double wall duct insulation values.

J. Exposed, rectangular, return-air duct insulation shall be one of the following:

1. Exposed return ductwork in conditioned areas does not require insulation.
2. Exposed return ductwork in unconditioned areas (mechanical rooms, garage, etc.) shall be provided with internal duct liner of sufficient thickness to provide R-4.2 rating.
3. Note: Ductwork designated to be double wall with perforated liner does not require exterior insulation as long as listed R-values are not by double wall duct insulation values.

K. Exposed, supply-air plenum insulation shall be one of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.
2. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

L. Exposed, return-air plenum insulation shall be one of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.
2. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

M. Exposed, outdoor-air plenum insulation shall be one of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.
2. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

3.13 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. Ducts and Plenums, Concealed:

1. None.

D. Ducts and Plenums, Exposed:

1. None.

END OF SECTION 230713

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following HVAC piping systems:

1. Condensate drain piping, indoors and outdoors.
2. Refrigerant suction and hot-gas piping, indoors and outdoors.

B. Related Sections:

1. Section 230713 "Duct Insulation."
2. Section 232113.13 "Underground Hydronic Piping."

1.2 ACTION 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. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

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.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.

D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.

1. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
2. Sheet Form Insulation Materials: 12 inches square.
3. Jacket Materials for Pipe: 12 inches long by NPS 2.

4. Sheet Jacket Materials: 12 inches square.
5. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. 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.

C. 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. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to 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 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.

C. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.

1. Piping Mockups:

a. One 10-foot section of NPS 2 straight pipe.
b. One each of a 90-degree threaded, welded, and flanged elbow.
c. One each of a threaded, welded, and flanged tee fitting.
d. One NPS 2 or smaller valve, and one NPS 2-1/2 or larger valve.
e. Four support hangers including hanger shield and insert.
f. One threaded strainer and one flanged strainer with removable portion of insulation.
g. One threaded reducer and one welded reducer.
h. One pressure temperature tap.
i. One mechanical coupling.

2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
3. Notify Architect seven days in advance of dates and times when mockups will be constructed.
4. Obtain Architect's approval of mockups before starting insulation application.
5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
7. Demolish and remove mockups when directed.

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 in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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 "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation 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. Calcium Silicate:

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Industrial Insulation Group (IIG); Thermo-12 Gold.
   b. Or approved equal.

2. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
3. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
4. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Pittsburgh Corning Corporation; Foamglas.
   b. Or approved equal.

2. Block Insulation: ASTM C 552, Type I.
3. Special-Shaped Insulation: ASTM C 552, Type III.
4. Board Insulation: ASTM C 552, Type IV.
5. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
6. Preformed Pipe Insulation with Factory-Applied ASJ: Comply with ASTM C 552, Type II, Class 2.
7. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

H. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Aeroflex USA, Inc.; Aerocel.
   b. Armacell LLC; AP Armaflex.
   c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.
   d. Or approved equal.

I. 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 one of the following:

a. CertainTeed Corp.; SoftTouch Duct Wrap.
b. Johns Manville; Microlite.
c. Knauf Insulation; Friendly Feel Duct Wrap.
d. Manson Insulation Inc.; Alley Wrap.
e. Owens Corning; SOFTR All-Service Duct Wrap.
f. Or approved equal.

J. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Fibrex Insulations Inc.; Coreplus 1200.
b. Johns Manville; Micro-Lok.
c. Knauf Insulation; 1000-Degree Pipe Insulation.
d. Manson Insulation Inc.; Alley-K.
e. Owens Corning; Fiberglas Pipe Insulation.
f. Or approved equal.

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.
3. Type II, 1200 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

K. Mineral-Fiber, Pipe Insulation Wicking System: Preformed pipe insulation complying with ASTM C 547, Type I, Grade A, with absorbent cloth factory-applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Knauf Insulation; Permawick Pipe Insulation.
b. Owens Corning; VaporWick Pipe Insulation.
c. Or approved equal.

L. 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 one of 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 equal.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Ramco Insulation, Inc.; Super-Stik.
    b. Or approved equal.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Ramco Insulation, Inc.; Thermokote V.
    b. Or approved equal.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.
    b. Or approved equal.

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. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-97.
    b. Eagle Bridges - Marathon Industries; 290.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-27.
    d. Mon-Eco Industries, Inc.; 22-30.
    e. Vimasco Corporation; 760.
    f. Or approved equal.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive 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."

C. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-84.
   b. Or approved equal.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive 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."

D. Phenolic and Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-96.
   b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-33.
   c. Or approved equal.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive 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."

E. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Aeroflex USA, Inc.; Aeroseal.
   b. Armacell LLC; Armaflex 520 Adhesive.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
   d. K-Flex USA; R-373 Contact Adhesive.
   e. Or approved equal.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Adhesive 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."

F. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements provide one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
   b. Eagle Bridges - Marathon Industries; 225.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
   d. Mon-Eco Industries, Inc.; 22-25.
   e. Or approved equal.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive 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."

G. ASJ Adhesive, and FSK and PVDC Jacket 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 one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
   b. Eagle Bridges - Marathon Industries; 225.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
   d. Mon-Eco Industries, Inc.; 22-25.
   e. Or approved equal.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive 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."

H. 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.
   b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
   c. P.I.C. Plastics, Inc.; Welding Adhesive.
   d. Speedline Corporation; Polyco VP Adhesive.
   e. Or approved equal.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive 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 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
   b. Vimasco Corporation; 749.
   c. Or approved equal.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. 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:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
   b. Eagle Bridges - Marathon Industries; 501.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-35.
   d. Mon-Eco Industries, Inc.; 55-10.
   e. Or approved equal.

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.
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

D. 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:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
b. Eagle Bridges - Marathon Industries; 570.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.
d. Or approved equal.

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.
5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
b. Eagle Bridges - Marathon Industries; 550.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
d. Mon-Eco Industries, Inc.; 55-50.
e. Vimasco Corporation; WC-1/WC-5.
f. Or approved equal.

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

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. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
c. Vimasco Corporation; 713 and 714.
d. Or approved equal.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
4. Service Temperature Range: 0 to plus 180 deg F.
5. Color: White.

2.6 SEALANTS

A. Joint Sealants:

1. Joint Sealants for Cellular-Glass, Phenolic, and Polyisocyanurate Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
   b. Eagle Bridges - Marathon Industries; 405.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Pittsburgh Corning Corporation; Pittseal 444.
   f. Or approved equal.

2. Joint Sealants for Polystyrene Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-70.
   b. Eagle Bridges - Marathon Industries; 405.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Or approved equal.

3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Permanently flexible, elastomeric sealant.
5. Service Temperature Range: Minus 100 to plus 300 deg F.
6. Color: White or gray.
7. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
8. Sealants 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. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
   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 equal.

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. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants 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."

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
   b. Or approved equal.

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: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants 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 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.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Chil-Glas Number 10.

b. Or approved equal.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Mast-A-Fab.
b. Vimasco Corporation; Elastafab 894.
c. Or approved equal.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

1. Products: Subject to compliance with requirements, provide one of the following:

a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.
b. Or approved equal.

2.10 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. 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.
b. P.I.C. Plastics, Inc.; FG Series.
c. Proto Corporation; LoSmoke.
d. Speedline Corporation; SmokeSafe.
e. Or approved equal.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: Color-code jackets based on system. Color as selected by Architect.
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.

D. Metal Jacket:

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
    b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
    c. RPR Products, Inc.; Insul-Mate.
    d. Or approved equal.

2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

    a. Sheet and roll stock ready for shop or field sizing.
    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.

3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

    a. Sheet and roll stock ready for shop or field sizing.
    b. Material, 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.

E. Underground Direct-Buried Jacket: 125-mil-thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Pittsburgh Corning Corporation; Pittwrap.
b. Polyguard Products, Inc.; Insulrap No Torch 125.
c. Or approved equal.

F. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white and stucco-embossed aluminum-foil facing.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Polyguard Products, Inc.; Alumaguard 60.
b. Or approved equal.

2.11 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 equal.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
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. FSK Tape: Foil-face, 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; 491 AWF FSK.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
c. Compac Corporation; 110 and 111.
d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
e. Or approved equal.

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. 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 equal.

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

D. 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 equal.

2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.12 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 equal.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.

3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

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:

a. C & F Wire.
b. Or approved equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. 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.

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.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. 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.
4. Manholes.
5. Handholes.

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 in Section 078413 "Penetration Firestopping" 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 in Section 078413 "Penetration Firestopping."

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 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.

3.11 FINISHES

A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

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.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

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 Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.12 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 Architect, 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.

3.13 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.

3.14 INDOOR PIPING INSULATION SCHEDULE

A. Refrigerant Suction and Hot-Gas Piping:
1. All Pipe Sizes: Insulation shall be one of the following:
a. Cellular Glass: 1-1/2 inches thick.
b. Flexible Elastomeric: 1 inch thick.
c. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.

B. Refrigerant Suction and Hot-Gas Flexible Tubing:
1. All Pipe Sizes: Insulation shall be one of the following:
a. Flexible Elastomeric: 1 inch thick.

3.15 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Refrigerant Suction and Hot-Gas Piping:
1. All Pipe Sizes: Insulation shall be one of the following:
a. Cellular Glass: 2 inches thick.
b. Flexible Elastomeric: 2 inches thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

B. Refrigerant Suction and Hot-Gas Flexible Tubing:
1. All Pipe Sizes: Insulation shall be one of the following:
a. Flexible Elastomeric: 2 inches thick.

3.16 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: All
1. None.

D. Piping, Exposed: All
1. PVC, Color-Coded by System: 30 mils thick.

3.17 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: All
1. Aluminum, Stucco Embossed: 0.032 inch thick.
2. Painted Aluminum, Stucco Embossed: 0.032 inch thick.

D. Piping, Exposed: All
1. Painted Aluminum, Stucco Embossed with Z-Shaped Locking Seam: 0.040 inch thick.
2. Stainless Steel, Type 304, Stucco Embossed with Z-Shaped Locking Seam: 0.024 inch thick.

END OF SECTION 230719

SECTION 230800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes commissioning process requirements for HVAC&R systems, Water Heating and Water Softening equipment and related accessories.

B. Related Sections:

1. Section 019113 "General Commissioning Requirements" for general commissioning process requirements.

1.2 DEFINITIONS

A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

B. CxA: Commissioning Authority.

C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.

D. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.3 INFORMATIONAL SUBMITTALS

A. Certificates of readiness.

B. Certificates of completion of installation, prestart, and startup activities.

1.4 ALLOWANCES

A. Labor, instrumentation, tools, and equipment costs for technicians for the performance of commissioning testing are covered by the "Schedule of Allowances" Article in Section 012100 "Allowances."

1.5 UNIT PRICES

A. Commissioning testing allowance may be adjusted up or down by the "List of Unit Prices" Article in Section 012200 "Unit Prices" when actual man-hours are computed at the end of commissioning testing.

1.6 CONTRACTOR'S RESPONSIBILITIES

A. Perform commissioning tests at the direction of the CxA.

B. Attend construction phase controls coordination meeting.

C. Attend testing, adjusting, and balancing review and coordination meeting.

D. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

E. Participate in Water Heating systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

F. Participate in Water Softening systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

G. Provide information requested by the CxA for final commissioning documentation.

H. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.7 CxA'S RESPONSIBILITIES

A. Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC&R systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

B. Provide Project-specific construction checklists and commissioning process test procedures for actual Water Heating systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

C. Provide Project-specific construction checklists and commissioning process test procedures for actual Water Softening systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

D. Direct commissioning testing.

E. Verify testing, adjusting, and balancing of Work are complete.

F. Provide test data, inspection reports, and certificates in Systems Manual.

1.8 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan:

1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.

2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.
4. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for Water Heating systems, assemblies, equipment, and components to be verified and tested.
5. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for Water Softening systems, assemblies, equipment, and components to be verified and tested.
6. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
7. Certificate of readiness certifying that HVAC&R systems, subsystems, equipment, and associated controls are ready for testing.
8. Certificate of readiness certifying that Water Heating systems, subsystems, equipment, and associated controls are ready for testing.
9. Certificate of readiness certifying that Water Softening systems, subsystems, equipment, and associated controls are ready for testing.
10. Test and inspection reports and certificates.
11. Corrective action documents.
12. Verification of testing, adjusting, and balancing reports.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

A. Certify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify that Water Heating systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

C. Certify that Water Softening systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

D. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

E. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

F. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

G. Inspect and verify the position of each device and interlock identified on checklists.

H. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

I. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.2 Testing AND BALANCING VERIFICATION

A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CxA.

B. Notify the CxA at least 10 days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.

C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.

1. The CxA will notify testing and balancing Contractor or Subcontractor 10 days in advance of the date of field verification. Notice will not include data points to be verified.
2. The testing and balancing Contractor or Subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.
3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.3 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the HVAC&R Contractor or Subcontractor, testing and balancing Contractor or Subcontractor, and HVAC&R Instrumentation and Control Contractor or Subcontractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.4 hvac&R systems, subsystems, and equipment Testing Procedures

A. Boiler Testing and Acceptance Procedures: Testing requirements are specified in HVAC boiler Sections. Provide submittals, test data, inspector record, and boiler certification to the CxA.

B. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence and Operations for HVAC Controls." Assist the CxA with preparation of testing plans.

C. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in HVAC piping Sections. HVAC&R Contractor or Subcontractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:

1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
2. Description of equipment for flushing operations.
3. Minimum flushing water velocity.
4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

D. Energy Supply System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of gas, chilled water / ice storage, hot-water and solar systems and equipment at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

E. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of chillers, cooling towers, refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

F. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.

G. Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.

END OF SECTION 230800

SECTION 230900 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 BAS SYSTEM DESCRIPTION

A. BAS Design Criteria: A new open, non-proprietary configurable Building Automation System (BAS) that includes the following:
   1. HVAC Control System
   2. Energy Management System
   3. Interface with the building's interactive LEED Educational Display panel
   4. Refrigerant Monitoring and Safety System
   5. Lighting Control System - Monitor only
   6. Fire Alarm System - Monitor only
   7. Security System - Monitor only
   8. Monitoring of all Water Meters, Electrical Meters and Natural Gas Meters at Utility Connection Routes.
   9. A single uniform Human Machine Interface (HMI) monitoring solution - Thermo Graphics or approved equal in functional look, feel, color and speed delivery that incorporates a linked, drill down, display / alarm capabilities from each individual floor zones through to individual system components and all systems being monitored.
   10. Use of the ANSI 709.1 LonTalk protocol at the field bus level of the architecture and ANSI/EIA 709.1, and ISO/IEC DIS 14908 LonTalk at the TCP/IP level.

B. The building automation binding tool will be Echelon LonMaker Turbo for Windows set up to be non-proprietary configuration and configurable.

C. The building automation system router shall be a Linksys / Cisco Gigabit Security Router or integrated network product that utilizes
   1. Virtual Private network (VPN)
   2. SPI Fire Wall and integrated Intrusion Prevention System (IPS).
   3. Supports 802.1Q Virtual Local Area Network (VLAN) and that has its own DHCP scope.

1.2 RELATED SECTIONS

A. Section 019113 – General Commissioning Requirements

B. Section 101400 – Signage

C. Section 230553 – Identification for HVAC Piping and Equipment

D. Section 230593 – Testing, Adjusting and Balancing for HVAC

E. Section 260010 – Basic Electrical Requirements

F. Section 260519 – Building Wiring and Cabling

G. Section 260800 – Electrical Commissioning

H. Section 260926 – Low-Voltage Lighting Control

I. Section 262726 – Wiring Devices

J. Section 263350 – Static Uninterruptable Power Supplies

K. Section 283100 – Fire Detection and Alarm

1.3 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION THAT REQUIRE BAS PROVIDER INTERFACE

A. Section 230519 – Meters and Gages for HVAC Piping:
1. Flow meters

B. Section 232113 – Hydronic Piping:
1. Temperature Sensor Wells and Sockets

C. Section 232300 – Refrigerant Piping:
1. Pressure and Temperature Sensor Wells and Sockets

D. Section 233300 – Air Duct Accessories:
1. Automatic Dampers

E. Section 230900 – Instrumentation and Control for HVAC:
1. Control Valves
2. Air Flow Stations
3. Terminal Unit Controls
4. Flow Switches
5. Control Dampers not part of equipment

1.4 PRODUCTS NOT FURNISHED OR INSTALLED BUT INTEGRATED WITHIN THE SCOPE THAT REQUIRE BAS PROVIDER INTERFACE

A. Section 101400 – Signage:
1. Building Interactive LEED Educational Display panel

B. Section 230514 – Variable Frequency Drives

C. Section 233600 – Air Terminal Units:
1. Cross Flow CFM Sensors
2. Terminal Actuator Control
3. Heat Exchanger Control

D. Section 260926 – Low-Voltage Lighting Control

E. Section __ ____ – __:
1. Fire Alarm System

F. Section __ ____ – __:
1. Security System

1.5 SUBMITTALS

A. Required Format for Submittals:
1. Shop Drawings and Product Data shall meet the requirements.
2. Shop drawings shall be 11 inch by 17 inch, landscape, bound on the left edge. They shall be produced with Microsoft Visio. Organize the packages by building and floors.
3. All text based documents and product data sheets shall be 8-1/2 inch by 11 inch format bound on the left edge. To the maximum extent possible Adobe Acrobat shall be used to produce the documents in an X.pdf format.
4. Software files shall be submitted on fully labeled CDs that shall include a table of contents file in pdf format that provides a description of all of the files on the CD and or USB Drive.
5. Requirement for Shop Drawings:
   a. System Architecture Design Diagram:
      1) This is a riser diagram that shall show the IP layers and all of the field bus layers.
      2) It shall show each computer, printer, router, repeater, controller and protocol translator that is connected to either the IP layer or any of the field busses.
      3) This diagram shall include the existing control system that is to be integrated into the common enterprise level system.
      4) Each component that is shown shall have a name that is representative of how it will be identified in the completed database and the manufacturer's name and model number. Example: Device A10: AHU1 Controller, XXX, IHM Model 1401Z0
      5) The physical relationship of one component to another component shall reflect the proposed installation.
         a) Example: If AHU-1 controller is the closest controller to the IP to LON router on the field bus, then this device shall be shown as the first device on the riser diagram just below the IP to LON router.
      6) This diagram shall not include power supplies, sensors or end devices.
   b. Layout Design Drawing for each control panel:
      1) The layout drawing shall be with all devices shown in their proposed positions.
      2) All control devices shall be identified by name.
      3) All terminal strips and wire channels shall be shown and labeled
      4) All control transformers shall be shown and labeled
      5) All 120 VAC receptacles shall be shown and labeled
      6) All IP connection points shall be shown and labeled
   c. Wiring Design Diagram for each control panel:
      1) The control voltage wiring diagram shall clearly designate devices powered by each control transformer. If the control devices use half-wave power, the diagram shall clearly show the consistent grounding of the appropriate power connection. All wire identification numbers shall be annotated on the diagram.
      2) The LON wiring diagram shall clearly show the use of the daisy chain wiring concept, the order in which the devices are connected to the LON and the location of end of segment termination devices. All wire identification numbers shall be annotated on the diagram.
      3) If shielded communication wiring is used, the grounding of the shield shall be shown.

4) The terminal strip wiring diagram shall identify all connections on both sides of the terminal strip. Wiring label numbers for all wiring leaving the control panel shall be annotated on the diagram.

d. Wiring Design Diagram for individual components (controllers, protocol translators, etc.):
1) The wiring diagram for each component shall identify all I/O, power and communication wiring, and the locations on the terminal blocks to which the wires are landed. Example: Fan Status sensor is wired from terminals 5/6 on the controller to terminals 17 and 18 on the terminal strip.

e. Installation Design Detail for each I/O device:
1) Include a drawing of the wiring details for each sensor and/or end device.
2) For devices with multiple quantities a standard detail may be submitted.
a) Note: The standard detail drawing must be accompanied by a list of the locations where the devices will be installed.

6. Requirements For Product Data:
a. Direct Digital Control System Hardware Technical Data.
1) A complete bill of materials of equipment to be used indicating quantity, manufacturer and model number.
2) Manufacturer's description and technical data for each unique device to include performance curves, product specification sheets and installation instructions. When a manufacturer's data sheet refers to a series of devices rather than a specific model, the data specifically applicable to the project shall be highlighted or clearly indicated by other means.
3) This requirement applies to:
a) Controllers
b) Transducers / Transmitters
c) Sensors
d) Actuators
e) Valves
f) Relays and Switches
g) Control Panels
h) Power Supplies
i) Batteries
j) Operator Interface Equipment

b. An Instrumentation List for each system:
1) The list shall be in a table format.
2) Include name, type of device, manufacturer, model number and product data sheet number.

c. Binding Map:
1) LonMaker Turbo drawings shall be 11 inch by 17 inch, landscape, bound on the left edge. They shall be produced with Microsoft Visio. Organize the packages by building and floors. The map will not need to include the flow of data from devices to the presentation system.

d. HMI/GUI Graphic Pages:
1) Submit a sample HMI/GUI graphic page for each type of page described in the specification section on graphic pages.

B. Turnover Documents after Completion and Commissioning:
1. The following is a list of post construction turnover documentation that shall be updated to reflect any changes during construction and re-submitted as "As-Built."
a. System architecture drawing.

b. Layout drawing for each control panel.
c. Wiring diagram for each control panel.
d. LonMaker Turbo Drawings
e. Wiring diagram for individual components.
f. System flow diagram for each controlled system.
g. Instrumentation list for each controlled system.
h. Sequence of controls.
i. Binding maps.

2. Operation and Maintenance Manuals:
   a. Operations and Maintenance Manuals shall consist of two parts. The information shall be in three ring binders with tabs and a table of contents. Diagrams shall be on 11" by 17" foldouts. If color has been used to differentiate information, the printed copies shall be in color.
   b. Part I: Information common to the entire system. This shall include but not be limited to the following.
      1) Product manuals for the key software tasks.
         a) Operating the system.
         b) Administrating the system.
         c) Engineering the operator workstation.
         d) Application programming.
         e) Engineering the network.
         f) Setting up the web server.
         g) Report creation.
         h) Graphics creation.
         i) All other engineering tasks.
      2) System Architecture Diagram.
      3) List of recommended maintenance tasks associated with the system servers, operator workstations, data servers, web servers and web clients.
         a) Define the task.
         b) Recommend a frequency for the task.
         c) Reference the product manual that includes instructions on executing the task.
      4) Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
      5) Licenses, guarantees, and warranty documents for equipment and systems.
      6) Submit one copy for each building, plus two extra copies.
   c. Part II: Information common to the systems in a single building.
      1) System architecture diagram for components within the building annotated with specific location information.
      2) As-built wiring design diagram for each control panel.
      3) As-built wiring design diagram for all components.
      4) Installation design details for each I/O device.
      5) As-built system flow diagram for each system.
      6) Sequence of control for each system.
      7) Binding map for the building.
      8) Product data sheet for each component.
      9) Installation data sheet for each component.
      10) Description of system commissioning protocol and procedures in binder with two extra copies.
      11) Initial system change control log in binder.
      12) Submit two copies for each building and two extra copies for file.

3. Software:
   a. Submit a LICENSED COPY of all software installed on the servers and workstations.
   b. Submit all licensing information for all software installed on the servers and workstations.
   c. Submit a LICENSED COPY of all software used to execute the project even if the software was not installed on the servers and workstations.
   d. Submit all licensing information for all of the software used to execute the project.
   e. All software revisions shall be as installed at the time of the system acceptance. All submittals will include all revisions
4. Firmware Files:
   a. Submit a copy of all firmware files that were downloaded to or pre-installed on any devices installed as part of this project.
   b. This does not apply to firmware that is permanently burned on a chip at the factory and can only be replaced by replacing the chip.
   c. Submit a LICENSED COPY of all application files that were created during the execution of the project.
   d. Submit an electronic copy on DVD of all graphic page files created during the execution of the project.
   e. Submit a copy of all secondary graphic files on DVD such as bitmaps, jpegs, etc. that were used in the creation of the graphic pages.

1.6 DEFINITION OF TERMS

A. Appendix A to this document contains a list of terms and/or abbreviations with their definitions. These terms are used throughout this document.

B. Additional definitions of terms or acronyms are included on the contract drawings and in other Sections of this specification.

C. In the preparation of submittals and reports, the contractor shall use these definitions and abbreviations. Any terms or abbreviations used by the BAS provider in submittals and reports that have not been defined in this section shall be defined by the BAS provider in the first section of the submittal or report prior to their use.

1.7 OWNERSHIP OF PROPRIETARY MATERIAL

A. The AOC shall retain all rights to any and all software and hardware used for this project.

B. The AOC shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to the AOC as defined by the manufacturer's licensing agreement. Standard language protecting the manufacturer's rights to disclosure of Trade Secrets contained within such software is acceptable.

C. The licensing agreement shall not preclude the use of the software by individuals under contract to the AOC for commissioning, servicing or altering the system in the future. Use of the software by individuals under contract to the owner shall be restricted to use on the AOC's computers and only for the purpose of commissioning, change control, servicing, or altering the installed system.

D. All project developed software, files and documentation shall become the property of the AOC. These include but are not limited to:
   1. Server and workstation software
   2. Application programming tools
   3. Configuration tools
   4. Network diagnostic tools
   5. Addressing tools
   6. Application files
   7. Configuration files
   8. Graphic files
   9. Report files
   10. Graphic symbol libraries
   11. All documentation
   12. All licensing

1.8 QUALIFICATIONS

A. Bids by wholesalers, distributors, mechanical contractors and non-franchised contractors shall not be acceptable without 5 years or more experience installing the proposed system.

B. All work described in the plans and specifications shall be installed, wired and commissioned by factory certified BAS technicians qualified for this work and in the regular employment of the control system manufacturer's local office.

C. A local office is defined as a corporate branch office or an independently owned office with a current contractual agreement with the system manufacturer that allows the office to purchase, install and service the manufacturer's products.

D. The local office shall be a full service facility within 142 miles of the project site. The local office shall be staffed with BAS engineers and technicians trained on the installation, commissioning and service of energy management and control systems based on the LON Works technology.

E. The building automation system (BAS/IP) design engineer must demonstrate expertise in the following:
   1. Six (6) years in Building Automation System (BAS) in the HVAC/Mechanical engineering field.
   2. Five (5) years of project management experience in similar types of facilities upgrade projects that involve Building Automation Systems (BAS), Energy Management (EM) and Heating, Ventilations and Air-conditioning (HVAC) systems.
   3. Four (4) years experience in the proprietary Building Automation System (BAS) Control Systems Design.
   4. Three (3) years of working experience with open industry standard, BAS control product lines.
   5. Two (2) years of project engineering experience with at least two major control system manufacturer's LonMark and LonTalk compliance standards
   6. One (1) year working experience with the California Building Energy Efficiency Standards, Nonresidential Compliance Manual.

1.9 QUALITY ASSURANCE

A. All work, materials, and equipment shall comply with the rules and regulations of all codes and ordinances of the local, state, and federal authorities. Such codes, when more restrictive, shall take precedence over these plans and specifications. As a minimum, the installation shall comply with the current editions in effect 30 days prior to receipt of bids for all of the Codes and Standards listed in Paragraph 1.6 of this specification.

B. Performance criteria for components, collections of components, communications and system performance are described in Part 2 - Products.

C. Key quality assurance BAS/IP Commissioning programs are described in Part 3 shall include the following
   1. Installation Component Verification
   2. Operational Testing Verification
   3. Performance Testing Verification
   4. Integrated Functional Testing Verification
   5. Commissioning Turnover Documentation package

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: Subject to compliance with requirements, provide products by one of the following:
   1. Manufacturers (Product Line):
      a. Schneider Electric; (TAC VISTA)
      b. Johnson Controls, Inc.; (Johnson Metasys®)
      c. Distech Controls Company; (EC-NetAX)
      d. Trane Company; (TRACER SUMMIT)
      e. Or approved equal

2.3 SYSTEM ARCHITECTURE

A. The DDC system shall include system servers, operator work stations, a data server, a web server and field level devices installed in an architecture that consists of two layers, the TCP/IP layer and the field bus layer.

B. The TCP/IP layer connects all of the buildings to the LAN and then interconnects all the buildings on a WAN or wide area network. Fixed IP addresses for connections to the LAN or local area network shall be used for each device (except workstations) that connects to the LAN or local area network

C. Connection points for the system servers, operator workstations, data server and web server shall be at the IP layer of the system architecture.

D. The system architecture shall include an IP to LON third party, configurable, "Loytec Redundant, EIA 709/IP Network Translator" and or pre-approved LonMark Certified Building Controller of comparable functional capabilities to connect a field bus to the LAN. A building control system shall have one or more IP connections to the LAN based on the number of connected devices and wiring considerations.

E. For the new building control systems, each LON field bus shall consist of one channel with no more than 78 connected devices. If there are more than 38 connected devices, the channel shall be divided into two segments separated by a physical layer, configurable "Echelon Repeater/Router" and or approved equal of comparable functional capabilities.

F. For the new building control systems, the programmable process controllers, supervisory logic controllers, application specific devices and protocol translators shall be installed on the field busses.

2.4 NETWORKING

A. IP Network: All new devices that connect to the LAN shall be capable of operating at 100 megabits per second or 1000 megabits per second. A legacy device connection speed of 10 megabits shall be accommodated on a case-by-case basis.

B. Field Bus:
1. The field busses shall be FTT-10A operating at 78 kilobits per second.
2. The wiring of components shall use (a preferred choice of) a properly terminated bus or daisy chain. Free topology networks (not a preferred choice) need exception preapprovals from the BAS-IP team at the time of submittal.
3. The wiring type and length limitations shall conform to Echelon's Junction Box and Wiring Guideline for Twisted Pair LonWorks Networks.

C. IP to Field Bus Router:
1. These devices shall perform layer 3 routing of ANSI/EIA 709.1B packets onto the IP network.
2. These devices shall be configurable locally without the use of the IP network (local cross over cable connection is acceptable) and configurable via the IP network.
3. These devices shall be configurable as routers such that only data packets from the field bus devices that need to travel over the IP level of the architecture are forwarded.

D. Building Controller:
1. These devices shall be configurable as routers such that only data packets from the field bus devices that need to travel over the IP level of the architecture are forwarded.
2. These devices shall provide the following support for the field bus devices that are connected below the building controller.
   a. Time schedules
   b. Trend logging
   c. Alarm message generation and handling
3. These devices may provide supervisory logic support for the field bus devices that are connected below the building controller.

4. These devices may have physical inputs and outputs and provide process control for systems using these inputs and outputs.
5. If a building controller has physical inputs and outputs, it shall also comply with all of the requirements for programmable process controllers.

E. Physical Layer Repeaters (PLR):
1. PLRs are required to connect two segments to create a channel.
2. The design of the PLRs shall conform to LONmark standards.
3. LON to LON routers configured as repeaters may be used as a PLR.
4. Physical layer repeaters shall be installed in an enclosure. The enclosure may be in an interstitial space.

2.5 FIELD BUS DEVICES

A. General Requirements:
1. Devices shall incorporate a service pin which, when pressed, will cause the device to broadcast its 48 bit node ID and its program ID over the network. The service pin shall be distinguishable and accessible.
2. Devices shall have a light indicating that they are powered.
3. Devices shall incorporate a TP/FT-10A transceiver in accordance with ANSI/EIA 709.3 and connections for TP/FT control network wiring.
4. Devices shall be locally powered. Link powered devices are not acceptable.
5. Application programs shall be stored in a manner such that a loss of power does not result in a loss of the application program or configuration parameter settings.

B. Programmable Process Controllers (PPC):
1. The key characteristics of a PPC are:
a. They have physical input and output circuits for the connection of analog input devices, binary input devices, pulse input devices, analog output devices and binary output devices. The number and type of input and output devices supported will vary by model.
b. They may or may not provide support for additional input and output devices beyond the number of circuits that are provided on the basic circuit board. Support for additional I/O may be by additional circuit boards that physically connect to the basic controller or by a standalone device that communicates with the basic controller via the FTT-10A field bus.
c. The application to be executed by a PPC is created by an application engineer using the vendor's application programming tool.
d. PPCs will support embedded time schedules. When time schedules are not embedded in a PPC, an occupancy command shall be an input network variable when time based control is required by the sequence of control
e. PPCs will support trend data storage with periodic upload to the data server. When trend data storage is not supported, the variables to be trended shall be broadcast over the field bus to another device that does support embedded trend data storage.
f. PPCs will support the initiation of an alarm message to the system server. When alarm message initiation is not supported, binary alarm indication variables shall be broadcast over the field bus to another device that does support the initiation of alarm messages to the system server.

2. Analog Input Circuits:
   a. The electrical signals from analog sensors shall be processed by an analog to digital (A/D) converter chip. The output of the A/D chip shall then be processed mathematically to produce data within the controller that has the required engineering units.
   b. The resolution of the A/D chip shall not be greater than 0.01 Volts per increment. For an A/D converter that has a measurement range of 0 to 10 VDC and is 10 bit, the resolution is 10/1024 or 0.00976 Volts per increment.
   c. For non-flow sensors, the control logic shall provide support for the use of a calibration offset such that the raw measured value is added to the (+/-) offset to create a calibration value to be used by the control logic and reported to the Operator Workstation (OWS).
   d. For flow sensors, the control logic shall provide support for the use of an adjustable gain and an adjustable offset such that a two point calibration concept can be executed (both a low range value and a high range value are adjusted to match values determined by a calibration instrument).
   e. For non-linear sensors such as thermistors and flow sensors the PPC shall provide software support for the linearization of the input signal.
3. Binary Input Circuits:
   a. Dry contact sensors shall wire to the controller with two wires.
   b. An external power supply in the sensor circuit shall not be required.
4. Pulse Input Circuits:
   a. Pulse input sensors shall wire to the controller with two wires.
   b. An external power supply in the sensor circuit shall not be required.
   c. The pulse input circuit shall be able to process up to 50 pulses per second.
5. True Analog Output Circuits:
   a. The logical commands shall be processed by a digital to analog (D/A) converter chip. The 0% to 100% control signal shall be scalable to the full output range which shall be either 0 to 10 VDC, 4 to 20 milliamps or 0 to 20 milliamps or to ranges within the full output range (Example: 0 to 100% creates 3 to 6 VDC where the full output range is 0 to 10 VDC).
   b. The resolution of the D/A chip shall not be greater than 0.04 Volts per increment or 0.08 milliamps per increment.
6. Pulse Width Modulation Outputs with PWM Transducers:
   a. The controller shall be able to generate incremental pulses as small as 0.1 seconds.
7. Binary Output Circuits:
   a. Single pole single throw or single pole double throw relays with support for up to 230 VAC and a maximum current of 2 amps.
   b. Voltage sourcing or externally powered Triacs with support for up to 30 VAC and 0.8 amps.
8. Program Execution:
   a. Process control loops shall operate in parallel and not in sequence unless specifically required to operate in sequence by the sequence of control.
   b. The sample rate for a process control loop shall be adjustable and shall support a minimum sample rate of 1 second.
   c. The sample rate for process variables shall be adjustable and shall support a minimum sample rate of 1 second.
   d. The sample rate for algorithm updates shall be adjustable and shall support a minimum sample rate of 1 second.

e. The application shall have the ability to determine if a power cycle to the controller has occurred, and the application programmer shall be able to use the indication of a power cycle to modify the sequence of control immediately following a power cycle.

9. Local Interface: The controllers shall support the connection of a portable interface device such as a laptop computer or vendor unique hand-held device. The ability to execute any tasks other than viewing data shall be password protected. Via this local interface, an operator shall be able to:
   a. Adjust application parameters.
   b. Edit time schedule parameters if time schedules are embedded in the controller.
   c. Execute manual control of input and output points.
   d. View dynamic data.
   e. View alarm messages if alarm messaging is embedded in the controller.
10. Each PPC shall have a network interface port that allows for an external device to connect to the FTT-10A network by plugging into the port. This port shall be built into the controller.

C. Supervisory Logic Controllers (SLC):
1. The key characteristics of an SLC are:
   a. The application to be executed by as SLC is created by an application engineer using the vendor's application programming tool.
   b. SLCs will support embedded time schedules. When time schedules are not embedded in a SLC, an occupancy command shall be an input network variable when time based control is required by the sequence of control.
   c. SLCs will support trend data storage with periodic upload to the data server. When trend data storage is not supported, the variables to be trended shall be broadcast over the field bus to another device that does support embedded trend data storage.
   d. SLCs will support the initiation of an alarm message to the system server. When alarm message initiation is not supported, binary alarm indication variables shall be broadcast over the field bus to another device that does support the initiation of alarm messages to the system server.
2. Program Execution:
   a. Control algorithms shall operate in parallel and not in sequence unless specifically required to operate in sequence by the sequence of control.
   b. The sample rate for algorithm updates shall be adjustable and shall support a minimum sample rate of 1 second.
   c. The application shall have the ability to determine if a power cycle to the controller has occurred and the application programmer shall be able to use the indication of a power cycle to modify the sequence of control immediately following a power cycle.
3. Local Interface: The controller shall support the connection of a portable interface device such as a laptop computer or vendor unique hand-held device. The ability to execute any tasks other than viewing data shall be password protected. Via this local interface, an operator shall be able to:
   a. Adjust application parameters.
   b. Edit time schedule parameters if time schedules are embedded in the controller.
   c. Execute manual control of input and output network variables.
   d. View dynamic data.
   e. View alarm messages if alarm messaging is embedded in the controller.

4. Each SLC shall have a network interface port that allows for an external device to connect to the FTT-10A network by plugging into the port. This port shall be built into the controller.
5. Programmable process controllers with un-used I/O may be used as supervisory logic controllers provided they meet all other requirements.
6. Supervisory logic controllers shall have support a minimum of 200 input network variables and 70 output network variables.
    a. The SNVT for each of the 200 input network variables shall be selectable.
    b. The SNVT for each of the 70 output network variables shall be selectable.
    c. For the input and output network variables there shall not be any limitations as to the SNVT selected. (Example: SNVT_temp_p can only be used on 10 input network variables.)

D. Application Specific Devices (ASD):
1. ASD shall have fixed function configurable applications.
2. If the application can be altered by the vendor's application programming tool, the device shall be considered a programmable controller and not an application specific device.
3. All input and output network variables shall be formatted with SNVTs.
4. All input configuration parameters shall be formatted with SNVTs or SCPTs. If UNVTs or UCPTs are used, the device resource files that allow these custom parameters to be read shall be provided to the owner.
5. The network interface shall conform to the LonMark profile for the application provided by the ASD.
6. Each ASD shall have a network interface port that allows for an external device to connect to the FTT-10A network by plugging into the port. This port shall be built into the controller.

E. Protocol Translators:
1. Protocol translators are required to interface third party equipment items such as chillers, boilers, power monitoring equipment, etc. to the new control system via the FTT-10A field bus.
2. Protocol translators shall convert the BACnet, Modbus or proprietary variables to/from the third party device to network variables that use SNVTs.
3. The application in a protocol translator shall include minimum send time and send on delta parameters for each reported variable to avoid data storms from the protocol translator.

2.6 DATA SERVERS, WEB SERVERS, DDC SYSTEM SERVERS AND WORKSTATIONS

A. Hardware Requirements:
1. General: The following minimum requirements apply to the system servers, data server, web server, operator workstations and appliances.
    a. Intel 7i Processor with 6 GB of RAM
    b. Rack Mounted Style Hewlett Packard or Dell servers with remote workstations
    c. Intel Motherboard or pre-approved equal
    d. Serial port, parallel port and 4 USB ports
    e. 10/100/1000 MBPS Ethernet NIC
    f. >750 GB Hard Disk Drive
    g. Mirroring Hard Disk Drives (Redundant Array Independent Disks)
    h. DVD-RW Drive

i. High resolution (minimum 1280 by 1024), >23.1 inch, LED flat panel wide screen display
j. Optical mouse and full function keyboard
k. Audio sound card and speakers
l. Surge protector / UPS with Powerchute manufactured by American Power Conversion Corporation (APC).

B. Software Requirements:
1. General: The following software with license agreements shall be provided.
2. System Servers:
a. Microsoft Windows Server 2003 operating system
b. Microsoft Office 2003 Professional Edition
c. DDC System Server Application, latest revision
d. Any other software required to deliver the specified performance.
3. Data Servers:
a. Microsoft Windows 2003 Server Operating System.
b. Microsoft SQL 2005
c. Microsoft Office 2003 Professional Edition
d. Echelon LonMaker Turbo Binding Tools
4. Web Server:
a. Microsoft Windows 2003 Server Operating System OR an embedded web server.
5. Operator Workstations:
a. Microsoft Windows Vista Professional Operating System
b. Microsoft Office 2003 Professional Edition
c. DDC System Operator Workstation Application(s) , latest revision
d. Any other software required to deliver the specified performance.
e. Echelon LonMaker Turbo

2.7 DDC SYSTEM SOFTWARE

A. System Servers: Software to provide the following functionality makes up the DDC System Server Application Software.
1. The system server shall manage the collection of data from a specific set of hardware devices and make that data available to the operator workstations and web server.
2. The system server shall manage the uploading of trend log data and transfer of this data to the data server.
3. For large systems with multiple system servers, each managing a portion of the hardware environment, a system server shall be able to send and receive data from other system servers that are part of the total system. Example: A demand control command from a controller under System Server # 1 is uploaded by System Server # 1 and then passed to System Server # 2 over the IP. System Server # 2 shall then pass the demand control command down to the controller where the command is required to execute the sequence of control.
4. The system architecture shall support up to 12 system servers.
5. The system server shall receive alarm messages from the hardware environment and distribute these messages to alarm files, printers, and email accounts as programmed. The received alarm shall cause trend data to be collected and reports to be automatically generated. Operator workstation software does not have to be running for these actions to take place.
6. The system server shall manage the execution of scheduled reports. Operator workstation software does not have to be running for reports to be written to the hard disk.

7. The system server software shall run as a service under the operating system for automatic start up after a power cycle of the system server computer.

B. Operator Workstations: Software to provide the following functionality makes up the DDC System Operator Workstation Application Software.
   1. Data Presentation: Data shall be presented in the following formats:
      a. Points lists with dynamic presentation of data. The operator shall be able to create custom point lists with data that originates from multiple devices. A point may be dynamic data from a controller or a configuration parameter to be written to a controller by the BAS operator.
      b. Graphic pages with dynamic presentation of data on a visual diagram that represents a building, a floor plan, a cross section of a mechanical system or a table of data.
      c. Graphical presentation of historical trend log data plotted against time.
      d. Graphical presentation of real time trend data plotted against time.
      e. Alarm Presentation:
         1) Unless restricted by a reduction in viewing authority, an operator shall be able to view alarms for all systems in a single alarm list.
         2) Custom alarm views configured for select categories of alarms shall present only the alarms specified.
         3) Alarm messages shall include identifying information and the signal value or state at the time of the alarm.
      f. Event Presentation:
         1) Unless restricted by a reduction in viewing authority, an operator shall be able to view an event log that chronologically captures all activity created by the system and operator actions.
         2) Custom event views for select categories of events shall present only the events specified.
      g. Time Schedules:
         1) Each time schedule shall have the ability to issue a minimum of 64 start and 64 stop commands for the week. The requirements for start and stop commands may be different for each day of the week.
         2) Each time schedule shall also include a holiday component where a holiday is identified by the date and duration (one day, two days, etc.). The time schedule shall support a unique set of start and stop commands for each holiday. The time schedule shall support a minimum of 72 holidays per year. Holiday schedules shall take precedence over standard schedules during the holiday period. Holidays that are date specific shall roll over from year to year without operator programming action.
         3) There shall be a mechanism to link a master time schedule editor at an OWS to multiple time schedules in various ATS devices (or Building Controllers). Once linked, whenever the master time schedule is changed at an OWS, the new time schedule parameters shall be automatically downloaded to all of the linked time schedules. This concept shall apply to both standard schedules and holiday schedules.
      h. The system shall support a configuration that:
         1) Causes the system to go into standby mode (user is logged out but the current screen is still displayed) after a specific period of inactivity.
         2) Causes an automatic system logout after a specific period of inactivity.

2. Data Source:
   a. An AOC BAS service provider operator workstation shall present data from all of the system servers.
   b. The system architecture shall allow a minimum of 1 BAS operator workstations and 2 LED monitoring screen stations per system if so specified on the drawings.
3. Operator Access And Privileges:
   a. There shall be a minimum of four privilege levels.
      1) BAS System Administrator:
         a) No limitations
         b) Only level that can assign or delete users and assign or modify privileges.
      2) BAS Engineer:
         a) View data in any format.
         b) Acknowledge alarms.
         c) Inhibit alarms.
         d) Exercise control actions.
         e) Edit the presentation of data.
         f) Modify the system.
      3) BAS Operator:
         a) View data in any format.
         b) Acknowledge alarms.
         c) Exercise control actions.
      4) BAS Viewer:
         a) View data in any format.
   b. The level assigned to a specific user shall be the maximum level that can be used anywhere in the system. The software shall provide the capability to reduce a user's level from his or her maximum level to a lower level on a per building or system basis.
   c. Signing on to the system shall require a user name and password. When the password is typed in, it shall not be shown on the screen.
   d. The system shall have the capability of using Windows NT Security logons in lieu of DDC system logons.
   e. The software shall provide the capability to establish groups of users with the same privileges. Once assigned to the group, the user shall automatically have the maximum privileges and the selectively reduced privileges assigned to the group.
   f. The software shall provide the capability to set user profiles that enable assigning a specific home graphic page, alarm view, and event view.
4. BAS Operator Actions:
   a. Given the appropriate authority, an BAS operator from an operator workstation shall be able to:
      1) View all data that is presented in the forms described previously.
      2) Acknowledge alarms.
      3) Manually control both physical input and physical output points.
      4) Edit both independent and master time schedules.
      5) Initiate real time trend logging.
      6) Manually initiate reports.
      7) Initiate system backups for the database and trend log data.
      8) Customize the layout of the operator workstation presentation which shall then be the default for that user.
   b. The BAS operator shall be able to execute the above tasks on data from any of the system servers via a single workstation.

c. The system shall support the use of Electronic Signature system wide or on selective tasks (change of values, manual control, trend initiation, etc.)
d. All of the BAS operator workstations shall be operable simultaneously. {You will want a license for each operator workstation so that all of the workstations can be used at the same time.}

5. Engineering Actions:
   a. The software shall, as a minimum, enable the following engineering functions from each of the operator workstations. If the task is followed by the annotation (#) where # is a number, the task must be executable from any combination of the workstations up to that number of workstations simultaneously.
      1) Create graphic pages for the presentation of dynamic data on visual images of buildings or equipment (2).
      2) Create reports for the presentation of historical data in an organized format (2).
      3) Create time schedules (2).
      4) Create trend logs in any of the field level devices and assign a dynamic variable from a field bus device to be trended (2).
      5) Setup long term storage of trend log data on the data server computer and the automatic transfer of the trend log data to the data storage tables in the SQL database (2).
      6) Create alarm objects in any of the field level devices, assign an alarm variable from a field bus device to initiate the alarm and set up the alarm routing (2).
      7) Configure and bring on-line a newly installed IP to LON router in support of an initial or incrementally added building control system (2).
      8) Configure and bring on-line a newly installed field level devices in support of an initial or incrementally added building control system (2).
      9) Create and download applications for programmable devices (2).
      10) Download firmware updates to field level devices.
      11) Import all field level devices into the system so that all input network variables, output network variables and adjustable application parameters can be accessed from any of the operator workstations (2).
      12) Bind variables from one field level device to a second field level device (2).
      13) Bind data from a field bus device under one IP connection to a field bus controller under a different IP connection (2).
      14) Configure the system to create backups of the database and all application and supporting databases on a scheduled basis (2).
      15) Setup user groups and individual users and establish authority levels for each group and individual user (2).
      16) Any additional tasks defined later in this document or required to deliver a fully functional system.

C. Web Server Software:
   1. This software shall enable BAS operators to access the system from remote computers using only Microsoft Internet Explorer. The software shall allow for a minimum of three (3) Once connected to the system, the operators shall be able to execute the following tasks.
      a. View dynamic data in a real time environment in both point list format and in a graphical page format.
      b. View and acknowledge alarms.
      c. Adjust time schedule parameters.

d. View historical trend data in table and graph formats.
e. View dynamic real time trends in graph format.
f. Run established reports.
g. Manually adjust application parameters.
h. Manually override physical inputs (sensor values) and force a specific value as an input to control logic.
i. Manually override physical outputs (end devices) and force a specific value regardless of the command from the control logic.

2. Enforced acknowledgement / response and electronic signature features shall apply to web delivered information.

D. Graphic Page Creation and Editing:
1. The Graphics Editor portion of the Engineering Software shall provide the following minimum capabilities:
a. Create and save symbols.
b. Create and save pages.
c. Group and ungroup symbols.
d. Modify an existing symbol.
e. Modify an existing graphic page.
f. Rotate and mirror a symbol.
g. Place a symbol on a page.
h. Place analog dynamic data in decimal format on a page.
i. Place binary dynamic data using state descriptors on a page.
j. Create motion through the use of gif files.
k. Place test mode indication on a page.
l. Place manual mode indication on a page.
m. Place links using a fixed symbol or flyover on a page.
1) Links to other graphics.
2) Links to web sites.
3) Links to notes.
4) Links to time schedules.
5) Links to any .exe file on the operator work station.
6) Links to .doc files.
n. Assign a background color.
o. Assign a foreground color.
p. Place alarm indicators on a page.
q. Change a symbol color as a function of an analog variable.
r. Change a symbol color as a function of a binary state.
s. Change symbols as a function of a binary state.
t. All symbols used by the contractor in the creation of graphic pages shall be saved to a library file for use by the owner.

E. Event Logging:
1. The BAS system shall maintain a log of all operator activity, system messages, alarms and alarm acknowledgments.
2. Operator activity is defined as any action by an operator such as changing the value of an application parameter, modifying a program, acknowledging an alarm, logging on, logging off, etc. Any change in the system caused by operator action shall be part of the log. The log shall include the event, the time of the event, the part of the system affected and an identification of the BAS operator and the OWS from which the change was made.

3. When the event deals with a value change, both the original and new values shall be part of the event record.
4. The Event Log shall be exportable to a report format that is printable.
5. The System Administrator shall be able to archive the event log.
6. The event data log shall comply with FDA CFR 21 - Part 11 requirements for data integrity.
7. The Event Log shall have a search function with assignable criteria to identify subsets of the event log such as all points placed under manual control, etc.

F. Alarm Generation And Processing:
1. Alarm creation is a two part process. The creation of a binary alarm indication is accomplished in a field level device where a binary state of zero shall indicate a normal condition and a binary state of one shall indicate an alarm condition. The binary alarm condition is read within a PPC, SLC, AH Device or Building Controller. The PPC, SLC, AH device or Building Controller shall assign a descriptive message, a category or priority number and a date and time stamp to the alarm and forward the information to the system server in accordance with an alarm routing table.
2. Alarm parameters such as high limits, low limits, time to state, binary alarm conditions are setup within the programming of the field level devices. These parameters shall be viewable and editable in point lists and on configuration graphic pages.
3. The BAS alarm message shall be descriptive.
   a. Building identification
   b. System identification
   c. Device identification
   d. Date
   e. Time to the second
   f. Nature of the alarm
      1) High value
      2) Low value
      3) Fail to start
   g. Value or state at the time of the alarm.
4. When the BAS operator acknowledges the alarm, there shall be an opportunity to enter a message that becomes a permanent part of the alarm record recorded in the event log.
5. The system shall support the association of graphic pages, trend charts, reports and text documents with specific alarms.
   a. The BAS operator shall have the ability to configure the system to auto-launch a specific graphic page when the alarm occurs.
   b. The system shall support the assignment of wav files to alarm signals on graphic pages.
   c. The BAS operator shall have the ability to launch a specific trend chart from the alarm window when the alarm occurs.
   d. The BAS operator shall have the ability to launch a specific text document when the alarm occurs.
   e. An associated report shall automatically execute and write to the hard disk on the OWS when the alarm occurs. Configurations options shall include overwriting the previous report or creating a new file.
6. The BAS system shall use selectable multiple colors on alarm messages for each of the following conditions:
   a. Alarm condition exists and has not been acknowledged
   b. Alarm condition has returned to normal but was never acknowledged
   c. Alarm condition exists and has been acknowledged.

7. When an BAS alarm condition no longer exists and has been acknowledged, it shall no longer be displayed in the alarm viewer but it shall be permanently recorded in the event list.
8. The Alarm Routing Table shall support the following:
    a. Multiple operators (based on OWS login) at any time.
    b. Specific operators (based on OWS login) at particular times (to include always as a choice).
    c. Pagers
    d. Email addresses via simple mail transfer protocol (SMTP; RFC 821)
    e. Permanent comprehensive system wide alarm file
    f. Specific alarm file based on a building or equipment identification
    g. One or more alarm printers at any time
    h. Specific alarm printers at specific times
    i. Rerouting of alarms to a backup receiver when an acknowledgement has not been entered into the system within a specified time.
9. The system shall have a default audible indicator generated by the computer when an alarm is received.
10. Once an alarm is acknowledged at one OWS, it shall display as acknowledged at all operator workstations.
11. An BAS operator shall be able to select multiple alarms for single action acknowledgement.
12. There shall be the ability to disable alarms and display all disabled alarms in a separate alarm view.
13. The OWS alarm viewer shall be able to display the last 100 active alarms. If there are more than 100 active alarms, as alarms are acknowledged and removed from the viewer, older alarms shall be viewable to keep the viewer showing the last 100 active alarms until there are less than 100 active alarms.

G. Trends:
1. Real Time Trends:
    a. At each OWS the operator shall be able to initiate a real time trending instance of up to 20 variables simultaneously.
    b. The polling interval setting shall be adjustable down to a rate of every second.
    c. The data for each instance shall be presented on a single graphical display that automatically updates with each new data collection cycle.
    d. The graphical presentation shall plot the variables on the Y axis and time on the X axis.
    e. A minimum of two Y axis scales shall be available.
    f. The operator shall have the ability to set the range on each Y axis scale or let the scales auto range to cover the range of the values being trended.
    g. Each element of data on the graphical display must be labeled by name or by a unique color. If color is used, a color legend must be included on the graph page.
    h. The BAS operator shall be able to open up to five instances simultaneously for a total of 100 points being trended at one time.
    i. An BAS operator shall be able to print an instance of real time data.
    j. The system shall be capable of trending any variable in the system.
    k. The BAS operator shall be able to save pre-configured instances of real time trending that can be initiated with simple point and click actions.
    l. The system shall provide the ability to expand the graphical presentation to full screen.

2. Historical Data Collection:
   a. Historical trend data shall be collected by field level devices and periodically uploaded to the data storage PC.
   b. The trend log objects in the field level devices shall have the capacity to store 300 samples per variable. When the 301st sample is collected, the 1st sample shall be discarded.
   c. The field level devices shall be configured to request an upload of data when the number of samples is not greater than 180. Uploads may be configured to occur at a greater frequency.
   d. Initiation of historical data collection shall be configurable.
      1) By manual operator intervention in a point and click manner.
      2) By a user adjustable time schedule or date.
      3) Triggered by a binary status variable (when the fan status is on, start the trend of the mixed air temperature).
      4) The system shall be capable of trending any variable in the system.
   e. The status and capacity of the trend logs in the field devices shall be viewable from the operator workstation.
3. Historical Data Presentation:
   a. An OWS shall have the capability to present the historical data for a variable in a tabular presentation of the values along with the date and time of the sample. The time period for the values to be presented shall be user adjustable.
   b. An OWS shall have the capability to present the historical data for a variable in a graphical presentation of the values plotted against time and date.
   c. The graphical presentation capabilities for historical trends shall equal those described above for real time trends.
   d. The BAS operator shall be able to save pre-configured instances of historical trending that can be initiated with simple point and click actions.
   e. The BAS operator shall be able to print the tabular presentations and graphical presentations of historical trend data.
   f. The system shall provide the ability to expand the graphical presentation to full screen.
4. The data collection, storage, retrieval and presentation system shall provide the features necessary for the AOC to achieve certification under Regulation 21 CFR Part 11 of the US Food and Drug Administration. (FDA) The key issue is the integrity of the data, the ability to verify that the data has not been modified after collection by the system.

H. Application Programming:
1. The application programming tool may be based on Line Programming or Graphical Programming concepts.
2. If the application programming is object based and graphical:
   a. There shall be an off-line simulation capability.
   b. There shall be the ability to view dynamic data displayed on the object diagram in real time.
3. There shall be self checking for errors in programming to be used by the programmer.
4. Key functions that must be supported are:
   a. Timer functions to include Delay Off, Delay On and Sample Rate Support
   b. Interval timer
   c. Math functions to include Addition, Subtraction, Multiplication, Division, Exponentiation, Trigonometric Functions and Logarithmic Functions (base 2 and base 10)
   d. If-Then-Else Instructions (also referred to as switching logic)

e. Look up tables with a minimum of 100 entries, with and without extrapolation
f. Bit Wise Logic
g. Sample and hold binary
h. Sample and hold analog
i. Latch on and latch off functions with resets
j. Input network variable definition
k. Output network variable definition
l. Sensor measurement definition
m. End device control definition
n. Logic functions to include And, Or, Not and Exclusive Or
o. Detection of a power cycle
p. Common function support (standard objects in graphical programs and subroutines in line programs). As a minimum the common functions shall include:
    1) PID with analog output
    2) PID with tri-state outputs
    3) Enthalpy from temperature and relative humidity
    4) Optimum start stop based on occupancy schedule, temperature, set point and outside air temperature.
    5) Polynomial equation
q. Search function.

I. Report Creation:
1. The BAS operators shall be able to extract historical data from the data collection files and present the data in a Microsoft Excel format. All of the data in the log shall be exportable to include the date, time and values
2. The number of trend logs that can be inserted into a single Excel Workbook shall not be limited by the OWS software.
3. The operators shall be able to pre-configure reports for manual execution or automated execution.
4. The OWS shall be able to auto execute any report based on:
    a. A time schedule
    b. An alarm trigger
    c. The status of a binary point (state=1, execute the report)
5. The BAS operators shall be able to pre-configure the destination of the report:
    a. OWS screen
    b. Write to file on the hard drive
    c. Send to a printer
6. The generation of a report shall not interrupt the use of the OWS by the operator, that is, it shall execute in the background.

J. Network Configuration Software:
1. Network Configuration Software shall be accessible from any operator workstation.
2. This software may be a separate software tool, multiple software tools or the functions may be integral to the engineering software.
    a. Functions that must be supported are:
        1) Addressing of field level devices
        2) Establishing data flow from device to device
        3) The ability to query a field bus and identify all installed devices by domain number, subnet number and node number.

3. If configuration of event driven communication is a function of the network configuration tool (in lieu of the application programs), the tool shall provide the capability to select the binding services used. See the definition of terms section for a discussion of binding services.

2.8 HVAC CONTROL HARDWARE IDENTIFICATION

A. Coordinate with the requirements of Section 230553 "Identification for HVAC Piping and Equipment."

B. Automatic Control Valve Tags:
1. Use metal tags with a 2-inch minimum diameter, fabricated of brass, stainless steel or aluminum. Attach the tags with a chain of the same material.
2. Stamp or engrave metal tags with color contrasting identification information
3. For lubrication instructions, use plastic laminated information / instruction sheets with nylon or ploy wrap ties
4. Tag the valves with identifying number and system information
5. Prepare a list of all tagged valves showing location, floor level, tag number and use. Organize the list by system. Include all tag information in all maintenance manuals.
6. Prepare a valve tag identification chart integrated with an single line diagram generated from the BAS as built drawings

C. Panels and Control Devices:
1. Control Panels (Enclosures) shall be labeled with stamped or engraved tags with contrasting color identification information permanently mounted on the panels.

D. HVAC Test and Balance Requirements:
1. The BAS provider shall provide the Test and Balance Contractor a single set of BAS test tools to interface with the control system for testing and balancing.
2. The BAS provider shall provide a minimum of 8 hours of training on the use of the BAS test tools.
3. The BAS provider shall provide a qualified BAS Test technician to assist with the testing and balancing of one system controlled by a programmable controller and the first ten terminal units.
4. The Test and Balance contractor is required to return the interface test tools unaltered and in working condition after completion of the testing and balancing.

2.9 GENERAL WORKMANSHIP REQUIREMENTS

A. The BAS provider shall install equipment, conduit, and wiring / raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.

B. The BAS provider shall provide sufficient slack and flexible connections to allow for vibration of piping, equipment and service loops.

C. The BAS provider shall install all equipment in readily accessible locations as defined by Chapter 1, Article 100 and Part A of the National Electrical Code (NEC).

D. The BAS provider shall verify the integrity of all wiring to ensure continuity and freedom from shorts and grounds.

E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

2.10 FIELD QUALITY CONTROL

A. All work, materials, and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Part 1 of this specification.

B. The BAS provider shall continually monitor the field installation for code compliance and quality of workmanship.

C. The BAS provider shall have work inspected by local and/or state authorities having jurisdiction over the work.

2.11 WIRING

A. All control and interlock wiring shall comply with national and local electrical codes and Division 25 of this specification. Where the requirements of this section differ from those in Division 27, the requirements of this section shall take precedence.

B. All NEC Class 1 (line voltage) wiring shall be UL Listed in approved raceway according to NEC and Division 26 requirements.

C. Low voltage wiring shall meet NEC Class 2 requirements. Sub-fuse low voltage power circuits as required to meet Class 2 current limits.

D. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL Listed for the intended application.

E. All wiring in mechanical, electrical, or service rooms, or where subject to mechanical damage, shall be installed in raceway at levels below 11 feet.

F. The BAS provider shall not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).

G. The BAS provider shall not install wiring in raceway containing tubing.

H. Where Class 2 wiring is exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 8 foot intervals.

I. Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.

J. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire to wire connections shall be at a terminal block.

K. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

L. Maximum allowable voltage for control wiring shall be 125 Volts. If only higher voltages are available, the contractor shall provide step-down transformers.

M. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

N. Install plenum wiring in sleeves where it passes through walls and floors. Maintain the fire rating at all penetrations.

O. The size of raceway and size and type of wire shall be the responsibility of the contractor, in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.

P. Include one pull string in each raceway that is 1 inch in diameter or larger.

Q. Use coded conductors throughout with conductors of different colors.

R. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

S. Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway, to maintain a minimum clearance of 9 inches from high-temperature equipment such as steam pipes, electrical transformers or flues.

T. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap, plumber tape or tie rods. Raceways may not be run on or attached to air distribution ductwork.

U. Adhere to specification requirements where raceway crosses building expansion joints.

V. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.

W. The BAS provider shall terminate all control and/or interlock wiring and shall maintain updated as-built wiring diagrams with terminations identified at the job site.

X. Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 2.5 feet in length and shall be supported at each end. Flexible metal raceway less than ½ inch electrical trade size shall not be used. In areas exposed to moisture, including chiller, pumps, chemical mixing and boiler rooms, liquid-tight, flexible metal raceways shall be used.

Y. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with coupling according to code. Terminations must be made with fittings at boxes and ends not terminating in boxes shall have protective bushings installed.

2.12 COMMUNICATION WIRING

A. The BAS provider shall adhere to the items listed in the previous section on WIRING.

B. The BAS provider shall install all cabling in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.

C. The BAS provider shall not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.

D. When a cable enters or exits a building, the BAS provider shall install a lighting arrestor between the lines and ground. The lighting arrestor shall be installed according to the manufacturer's instructions.

E. The BAS provider shall install all runs of communication wiring with un-spliced lengths when that length is commercially available.

F. The BAS provider shall provide a permanent tagged label on all communication wiring to indicate origination and destination data.

G. The BAS provider shall ground coaxial cable in accordance with NEC regulations on "Communications Circuits, Cable, and Protector Grounding."

H. When shielded wiring is use, the BAS provider shall ground the shield only once for each continuous segment of cable. The grounding location shall be at the end of the segment that is most readily accessible.

2.13 SENSORS

A. The BAS provider shall install sensors in accordance with the manufacturer's recommendations.

B. The BAS provider shall mount sensors rigidly and adequately for the environment within which the sensor operates.

C. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.

D. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

E. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.

F. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across the duct. Each bend shall be supported with a stainless steel capillary clip. Provide 1 foot of sensing element for each square foot of coil area.

G. All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in the thermal wells.

H. Install outdoor air temperature sensors on the north wall, complete with a sun shield at the designated location.

I. Differential Air Static Pressure Sensors:
   1. For supply duct static pressure, pipe the high pressure tap to a duct probe that measures at a 90-degree angle +/- 5 degrees to flow (to measure only the static pressure and not the effects of velocity). Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor if one is installed or to the plenum if a building static pressure sensor is not installed.
   2. For return duct static pressure, pipe the high pressure tap to a duct probe that measures at a 90-degree angle +/- 5 degrees to flow (to measure only the static pressure and not the effects of velocity). Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor if one is installed or to the plenum if a building static pressure sensor is not installed.
   3. For building static pressure, pipe the low-pressure port of the sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.
   4. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
   5. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels and not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without the use of ladders or special equipment to the maximum extent possible.
   6. All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shutoff valves installed before the tee.

J. Annular pilot tubes shall be installed so that the total head pressure ports are set-in-line with the pipe axis upstream and the static port facing downstream. The total head pressure ports shall extend diametrically across the entire pipe. Annular pilot tubes shall not be used where the flow is pulsating or where pipe vibration exists.

2.14 FLOW SWITCHES

A. Airflow Switches:
   1. Install in horizontal duct runs whenever possible.
   2. If a vertical duct run is the only option, then install in a location with an upward airflow.

B. Hydronic Switches:
   1. Use the correct paddle type for the pipe diameter as described by the switch manufacturer.
   2. Adjust the flow switch in accordance with the manufacturer's instructions.

2.15 ACTUATORS

A. Damper actuators manufactured by Belimo featuring Multi-Function Technology for HVAC or approved comparable product of equal functional reliability and warrantee duration.

B. Damper actuators shall be provided with all appropriate mounting hardware and linkages.

C. Mount and link control damper actuators according to manufacturer's instructions.

D. When spring return actuators are used on normally closed dampers, the seals shall be compressed when the dampers have been closed by the actuator.

E. Damper / actuator combinations shall modulate smoothly from fully closed to fully open and return.

F. Electric / Electronic Control valves shall be manufactured by Belimo, Model Type, PICCV design with a five year warranty or approved comparable product of equal functional reliability and warrantee duration.
   1. Shall be mounted following the actuator manufacturer's recommendations.

2.16 IP INTERFACE DEVICES

A. Install IP to LON Routers or Building Controllers for each required connection to the owner's TCP/IP network. Locations are identified on the drawings.

B. The IP to LON Routers or Building Controller shall be configured and commissioned to ensure that the only data traffic on the TCP/IP is data that is essential for operation of the system. Messages between field devices on the same field bus shall not be allowed to pass onto the TCP/IP network.

2.17 CONTROLLERS

A. Install programmable process controllers, supervisory logic controllers and application specific devices on each field bus to meet the requirements of the sequence of control for all systems.

B. All process control loops for an integral system shall reside in a single controller. Each controllable end device creates one process control loop. Examples of integral systems are:
   1. Packaged Make-up Air Units
   2. Variable Refrigeration Flow Units/System
   3. Exhaust Fans
   4. Variable Speed Drives
   5. Lighting Control Systems (Panels)
   6. Energy Management Monitoring Devices
   7. Central Plant Optimization System
   8. Electrical Meters
   9. Water Meters
   10. Natural Gas Meters

C. To the maximum extent possible, all process control loops for built up systems shall reside in a single controller. An example is a chiller with its associated chilled water and condenser water pumping systems or a boiler system with steam to hot water heat exchangers. The objective of this requirement is that the contractor shall use large point count, primary controllers in lieu of multiple secondary controllers.

D. Supervisory logic for integral and built up systems may reside in separate supervisory logic controllers with the output commands to the process control loops traversing the field bus to the controllers executing the process control.

2.18 CONTROL DAMPERS

A. Install dampers in accordance with the manufacturer's instructions to operate and to obtain leakage rates specified herein. Adjust the damper linkage such that the damper closes before the Belimo or approved equal actuator is fully closed to assure tight shutoff of the damper.

B. Blank-off and seal around dampers and between dampers and sleeves or frames with EPA and CARB approved, low VOC solvent based, sealants to eliminate air bypass leakage.
   1. Note: No water base sealants are acceptable

C. For outdoor air damper assemblies, stage the opening of each section to prevent stratification and poor mixing of outside and return air.

2.19 CONTROL VALVES

A. Install in an accessible location, with room for actuator removal and service. Adjust the actuator to provide tight shutoff. Provide visible, color coded, valve stem indicator and adjust to indicate proper travel.

B. Where butterfly valves are used, permanently mark the end of the valve shaft to indicate the valve position.

C. Control Valves:
   1. All automatic control valves shall be fully proportioning and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All valves shall operate in sequence with another valve when required by the sequence of operations. All control valves shall be sized by the control manufacturer, and shall be guaranteed to meet the heating and cooling loads, as specified. All control valves shall be suitable for the system flow conditions and close against the differential pressures involved.
   2. Water control valves shall be modulating plug, ball, and/or butterfly, as required by the specific application. Modulating water valves shall be sized per manufacturer's recommendations for the given application. In general, valves (2 or 3-way) serving variable flow air handling unit coils shall be sized for a pressure drop equal to the actual coil pressure drop, but no less than 5 PSI. Valves (3-way) serving constant flow air handling unit coils with secondary circuit pumps shall be sized for a pressure drop equal to 25 percent the actual coil pressure drop, but no less than 2 PSI. Mixing valves (3-way) serving secondary water circuits shall be sized for a pressure drop of no less than 5 PSI. Valves for terminal reheat coils shall be sized for a 2 PSIG pressure drop, but no more than a 5 PSI drop.
   3. Modulating plug water valves of the single-seat type with equal percentage flow characteristics shall be used for all hot and chilled water applications, except those described hereinafter. The valve discs shall be composition type. Valve stems shall be stainless steel.
   4. Ball valves shall be acceptable for water terminal reheat coils, radiant panels, unit heaters, package air conditioning units, air handling units, and fan coil units.
   5. Butterfly valves shall be acceptable for modulating large flow applications greater than modulating plug valves, and for all two-position, open/close applications. In-line and/or three-way butterfly valves shall be heavy-duty pattern with a body rating comparable to the pipe rating, replaceable lining suitable for temperature of system. Valves for modulating service shall be sized and travel limited to 50 degrees of full open. Valves for isolation service shall be the same as the pipe. Valves in the closed position shall be bubble-tight.

2.20 AIRFLOW / TEMPERATURE MEASURING DEVICES

A. Manufacturers:
1. Ebtron, Inc.
2. Kurz Instruments.
3. Sierra Instruments.
4. FCI.

B. Provide one thermal dispersion airflow / temperature measurement device (ATMD) at each location indicated on the plans, schedules and/or control schematics.
1. Fan inlet measurement devices shall not be used unless indicated on drawings or schedules.
2. Each ATMD shall consist of one to four sensor probes and a single, remote transmitter. Each sensor probe shall consist of one to eight independent sensor nodes in a gold anodized, aluminum 6063 alloy tube with 304 stainless steel mounting brackets.
3. Each sensor node shall consist of two hermetically sealed bead-in-glass thermistors. Chip thermistors of any type or packaging are not acceptable.
4. The temperature output of the ATMD can be used in place of the specified temperature measuring device (TMD) when the location of the ATMD and TMD are effectively the same.
5. Sensor Density Requirements:
   a. Sensor density (#/area) affects minimum installed distances required from disturbance types. Published sensor density data by the product manufacturer shall be submitted for approval.
   b. Should there be no published document indicating these relationships for a particular product, the number of individual sensor nodes provided for each rectangular location shall be as follows:

Duct or Plenum Area (ft^2)	Total # Nodes / Location	Duct or Plenum Area (m^2)
<= 1	**1 or 2**	<= 0.093
>1 to <4	**4**	>0.093 to < 0.372
4 to < 8	**6**	0.372 to < 0.743
8 to < 12	**8**	0.743 to < 1.115
12 to <16	**12**	1.115 to < 1.486
>=16	**16**	>= 1.486

   c. The number of individual sensor nodes for each rectangular location shall be maximized for performance within the placement conditions provided. In no instance shall field selected locations provide less distance between disturbances than required for maximum performance. When minimum distances allowed by the highest density of sensor distribution are exceeded, a lower density configuration that provides the same performance is acceptable.
   d. The number of individual sensor nodes provided for each round or oval duct location shall approximate the total required for rectangular locations or be detailed in published documentation by the manufacturer.
   e. Submittal documents shall include schedules indicating the number of sensors per location, the duct area and the equivalent density (#/area) for approval.
6. Thermistors shall be potted in an engineering thermoplastic assembly using water-proof, marine epoxy and shall not be damaged by moisture or direct contact with water.
7. Signal processing circuitry on or in the sensor probe is not acceptable.

8. Each sensing node shall be individually wind tunnel calibrated at 16 points to NIST traceable airflow standards.
9. Each sensing node shall be individually calibrated in constant temperature oil baths at 3 points to NIST traceable temperature standards.
10. All internal wiring between thermistors and probe connecting cables shall be Kynar jacketed.
11. Manufacturer shall provide UL listed, FEP jacketed, plenum rated cable(s) between sensor probes and the remote transmitter.

C. Measurement Performance:
1. Each sensing node shall have a temperature accuracy of $\pm$ 0.14 deg F (0.08 deg C) over the entire operating temperature range of -20 deg F to 160 deg F (-28.9 deg C to 71 deg C).
2. Each sensing node shall have an airflow accuracy of $\pm$ 2% of reading.
3. The ATMD shall be capable of measuring airflow rates over the full range of 0 to 5,000 FPM (25.4 m/s) between -20 deg F to 160 deg F (-28.9 deg C to 71 deg C).

D. Integral Transmitter and Communications:
1. The transmitter shall be powered by 24 VAC, be over-voltage and over-current protected, and have a watchdog circuit to provide continuous operation after power failures and/or brown-outs.
2. The power requirement for the ATMD shall not exceed 22 V A.
3. The transmitter shall determine the airflow rate and temperature of each sensing node prior to averaging.
4. The transmitter shall have two isolated and fused analog output signals and one RS-485 network connection.
5. Each analog output shall be field configurable as linear 0-5/1-5 VDC, 0-10/2-10 VDC or 4-20mA signals.
6. The RS-485 network connection shall be field configurable as BACnet MS/TP or Modbus RTU.
7. The RS-485 connections shall transmit the average airflow rate, average temperature, individual airflow rates of each sensor node, and individual temperatures of each sensor node and system status.
8. All integrated circuits shall be industrial rated for operation down to -40 deg F (-40 deg C).
9. All electrical plugs, receptacles and circuit board interconnects shall be gold plated.

E. Listings and Certifications:
1. The ATMD shall be UL 973 listed.
2. The ATMD shall be BTL listed.

F. The manufacturer's authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans, prior to fabrication and installation.
1. A written report shall be submitted to the consulting mechanical engineer if any measurement locations do not meet the manufacturer’s placement requirements.

2.21 CARBON MONOXIDE, CARBON DIOXIDE AND NITROGEN DIOXIDE DETECTION AND CONTROL SYSTEMS FOR PARKING STRUCTURES

A. Multi-Point Analog Systems are best for small-to-medium size areas (15,000 to 90,000 sq ft). The system can monitor multiple gas sensors and control multiple relays for fan control. All sensor wiring is home run to the multi-point controller using two-wire (three-wire for combustible gas transmitters) shielded cable. The controller should be capable of providing multiple relay outputs for fan control and have multiple analog outputs to control VFDs. Provide complete system with INTEC or equal control system.

B. System shall include Monitor / Controller(s) time zone capability (INTEC-MGC2), CO, NO_2 and CO_2 sensors, VFD for control(s), strobe and horns, all required wiring, and connections to building automation system (LON).

2.22 PROGRAMMING FOR PROGRAMMABLE DEVICES

A. These requirements apply to Building Controllers, programmable process controllers, supervisory logic controllers, automatic time scheduling devices, trend logging devices, alarm handling devices and automatic time schedule switch-over devices.

B. The BAS provider shall create and download application programs that meet the requirements of the sequence of control, time scheduling requirements, trend logging requirements and alarm handling requirements.
   1. The BAS provider shall use a consistent point naming concept throughout the project that allows for easy transition from building to building and system to system.
   2. The BAS provider shall employ extensive code annotation for each functional block, signal and device. The owner shall be able to easily recognize the function of each functional block, signal in or out of any device or the device itself.
   3. All time schedules shall be fully configured with weekly schedules and all of the holidays identified by the AOC.
   4. All trend logs identified in the sequence of control shall be fully configured and operational.
   5. All alarm handling shall be fully configured with consistent alarm messages and priorities or category numbers to identify the system from which the alarm originates.
   6. All application parameters identified as (adj) in the sequence of control shall be exposed as viewable parameters using LonTalk network variables with an appropriate SNVT and appropriate initial values shall be set.
   7. All external point values and internal point values identified as (rpt) in the sequence of control shall be exposed as viewable values using LonTalk network variables with an appropriate SNVT.
   8. Manual control of all external points (and those internal points requiring manual control) shall be programmed using either the priority override concept or the software switchover concept (See the definition of terms section for a discussion of these two concepts). The network variables that communicate manual control commands from the OWS to the controllers shall be LonTalk variables with an appropriate SNVT. Proprietary implementation of manual control is not acceptable.
   9. For all variables broadcast onto the field bus, event driven communication shall be used to avoid data storms. As a minimum the program shall provide for the send on delta parameter and minimum send time parameter for each output variable.

10. The BAS provider shall embed into the programs sufficient comment statements to clearly describe each section of the program. This applies to both line programming and graphical programming systems.
11. If graphical programming systems with multiple layers for the functional block diagrams are used, no more than two layers shall be used.

2.23 CONFIGURATION OF APPLICATION SPECIFIC DEVICES

A. Application specific devices shall be configured to meet the sequence of control.

2.24 DEVICE-TO-DEVICE DATA FLOW

A. All device-to-device data flow shall be in place and configured to meet the sequence of control for the new systems and to integrate the existing systems.

B. All device-to-device data flow shall be implemented through the use of LonTalk variables with an appropriate SNVT (Standard Network Variable Type). Proprietary data flow from device to device is not acceptable.

C. Appropriate binding services shall be used to ensure that the average bandwidth utilization is less than 30%. The owner reserves the right to conduct network bandwidth testing to ensure this requirement is met.

D. If reducing the number of devices per field bus is required to meet the network bandwidth requirements, all costs of making changes shall be borne by the contractor.

2.25 DISTRIBUTED CONTROL REQUIREMENTS

A. The programmed applications for a single integrated system shall not be distributed over more than one field bus. Examples:
1. A chiller is controlled by a controller on field bus number 1. The controllers that control the pumps and tower shall also be on field bus number 1 as these systems are integrated in their control requirements.
2. Multiple air handling units are controlled by controllers on field bus number 1. The chiller system is controlled by controllers on field bus number 2. The chiller control logic requires the chilled water valve positions from each of the air handling unit controllers. It is acceptable that these related but non-integral systems are controlled by controllers on different field busses.

2.26 SYSTEM UNITS AND RESOLUTION

A. The BAS provider shall use SNVTs with the appropriate units for each input network variable, input application parameter and output network variable.

B. The BAS provider shall use SCPTs with the appropriate structure for each input application parameter that is based on the SCPT (Standard Configuration Property Types) concept.

C. The UMCS must communicate with the operators visually and in reports using the inch-pound system.

D. The conversion of data from a field level device must be automatically converted from SI units to inch-pound units prior to display.

E. For BAS operator initiated values, the BAS operator shall be able to enter values in units from the inch-pound system of units and the system must then automatically convert the value to units from the SI system of units for dispatch to the field level devices.

F. The system must be able to display values visually or in reports with a resolution equal to the resolution of the data as defined in the SNVT Master List or the SCPT Master list. Where conversion from the SI system to the Inch-Pound system of units results in a two numeric digit resolution, the resolution of display must be equal to the rounded up value. Example: SNVT temp data has a resolution of 0.01 degrees C. This is a single digit resolution. Upon conversion to degrees F, the resolution would be 0.018 degrees F. This is a two digit resolution. The round up process would produce a required resolution for display of 0.02 degrees F.

2.27 SERVERS AND BAS WORKSTATIONS

A. The BAS provider shall install:
1. System servers and operator work stations as shown on the contract drawings.
2. A data server and a web server as shown on the contract drawings (and they can also occasionally be one appliance device)

B. All required software for fully functional systems shall be installed and configured. The owner shall provide the IP connections and identify the specific rooms where the computers shall be installed.

2.28 SYSTEM SERVER

A. All field level devices shall be addressed and imported into the system server database.

B. For the existing control system that is being integrated into the new system, the addresses of the existing field devices shall not be changed.

2.29 BAS OPERATOR WORKSTATIONS

A. Dynamic Data Displays:
1. Points lists shall be organized on a per field device basis.
2. If the software provides for the sub-division of point data within a field device, the data shall be organized by physical sub-system as a minimum (fan section, mixed air section, etc.).
3. The workstation shall be configured to automatically update values without any action by the operator.
4. Value updates in points lists shall be configured to update at least once every 5 seconds.
5. Binary data shall be configured to display state descriptors (OFF, ON; OPEN, CLOSED; etc.) and not the states of 0 and 1.
6. Analog data shall display with a resolution equal to the resolution defined as part of the SNVT used to transmit the data.
7. Analog data displays shall include engineering units.
8. All text fields associated with a specific element of data shall be filled out to provide the maximum amount of information to the operator.

B. Color Graphic Pages:
1. Hierarchy:
a. The organization of graphic pages shall be from a global level down to a very detailed level through a series of links.
b. Linking shall allow the operator to move down the hierarchy, up the hierarchy and laterally within the hierarchy.
2. Hierarchy Outline:
a. Site Plan Page: A visual representation of the site (map). One page or multiple linked pages depending on the size of the site plan.
1) Link to individual building graphic pages.
2) Display outdoor weather conditions.
b. Utility Management Page: A summary of data on the utility consumption for the site.
1) Link up to the site plan.
2) Display:
a) Utility consumption data.
b) Demand data.
c) Voltages, currents and power factors.
d) Demand control actions currently in effect.
3) Presenting the utility management data may require more than one graphic page to effectively report the data from multiple meters.
c. Building Graphic Page: Typically a picture of the building. One page per building.
1) Link to floor plans within the building.
2) Link to central plant graphics where the plant serves the entire building.
3) Link to delivery systems if the delivery system serves the entire building
4) Link up to the site plan.
d. Floor Plan Page: This will be a two dimensional plan of a floor area. A minimum of one page per floor per building is required. Where floor plans are large, multiple linked pages are required. For each control zone the value of the controlled parameters shall be displayed. This will typically be lighting status, temperature and relative humidity if relative humidity is a controlled variable.
1) Link up to the Building page.
2) Link up to the Site Plan page.
3) Link to any delivery system that serves the floor plan area (air handling unit is typical).
4) Link to time schedules that affect the systems that serve the area
5) Link to a Terminal Unit Summary page where multiple zones on the floor are served by unitary control devices such a VAVs or fan coil units.
6) Individual control zones shall be identified.
7) The location of terminal equipment serving each zone shall be shown.
8) The location of sensors installed in the occupied space shall be shown.
9) Where room numbers are available, they shall be shown.
e. Central Plant Page: A graphical representation of the equipment that makes up the plant such as chillers, pumps, boilers, etc. If the plant is small, this graphic will display the values of process variables and commands to end devices. If the plant is complex this graphic will just contain links to equipment graphics. A page for each plant is required.
1) Link up to the Building page.
2) Link up to the Site Plan page.
3) Link to Central Plant Equipment Component page (chiller, pumps, tower, etc.).

4) The graphic representation of the equipment shall be 3-dimensional.
5) Display:
   a) Process variables.
   b) Commands to end devices.
   c) Status of end devices.
   d) Alarm points if this is the only central plant graphic.
   e) Plant status (enabled / disabled).
   f) Demand control status.
6) Link to any time schedules that affect the operation of the plant.
7) Link to any pre-configured trend charts associated with the performance of the plant.
8) Link to a Central Plant Configuration Page.

f. Central Plant Equipment Component: A graphical representation of an element of equipment such as a chiller, pumps, boiler or tower or some combination of all of these. A page for each primary equipment item per plant is required.
1) Link up to the Central Plant page.
2) Link up to the Building page.
3) Link up to the Site Plan page.
4) The graphic representation of the equipment shall be 3-dimensional.
5) Display:
   a) Process variables.
   b) Commands to end devices.
   c) Status of end devices.
   d) Alarm points.
   e) Equipment status (enabled / disabled).
   f) Demand control status.
6) Link to any time schedules that affect the operation of the equipment component.
7) Link to any pre-configured trend charts associated with the performance of the equipment component.
8) Link to a Central Plant Configuration Page.

g. Central Plant Configuration Page: On this page the operator is given access to the configuration parameters for the entire plant or a piece of equipment in the plant. Typically, this page presents data in a tabular format. The type of data on this page is not changed frequently, but the operator may wish to view it frequently. One page per plant for small plants and one page per primary equipment item per plant for larger plants are required.
1) Set Points.
2) Tuning Parameters.
3) Calibration Parameters.
4) Timing Parameters.
5) Application parameters.
6) Reset Schedules.
7) Lead Lag Information.
8) Time Schedules.
9) Link up to the Equipment or Central Plant page.
10) Link up to the Building page.

h. Delivery System Page: A graphical representation of an air or water delivery system such as an air handling unit, roof top air handling unit, computer room air conditioning unit. One page for each delivery system.
   1) If the Delivery System serves a specific floor area, link up to the Floor Area page.
   2) Link up to the Building page.
   3) Link up to the Site Plan page.
   4) Link to the Central Plant page if the Delivery System is served by a Central Plant.
   5) If the Delivery System supplies multiple terminal devices, link to a Terminal Unit Summary page.
   6) Link to a Delivery System Configuration page.
   7) The graphical representation of the equipment shall be 3-dimensional and represent the true physical characteristics of the installed system.
   8) Display:
      a) Process variables.
      b) Commands to end devices.
      c) Status of end devices.
      d) Status of different modes (economizer on/off, mechanical cooling enabled / disabled, occupied / unoccupied).
      e) Alarm points.
   9) Link to any time schedules that affect the system operation.
   10) Link to any pre-configured trend charts for the system.

i. Delivery System Configuration Page: On this page the AOC service provider operator is given access to the configuration parameters for the delivery system. Typically, this page presents data in a tabular format. The type of data on this page is not changed frequently, but the operator may wish to view it frequently. One page per delivery system is required.
   1) Display:
      a) Set Points.
      b) Tuning Parameters.
      c) Calibration Parameters.
      d) Timing Parameters.
      e) Application parameters.
      f) Reset Schedules.
      g) Lead Lag Information
      h) Time Schedules.
   2) Link up to the Delivery System page.
   3) Link up to the Building page.
   4) Link up to the Site Plan page.

j. Terminal Equipment Summary Page: On this page the dynamic data and set points that are associated with multiple terminal units are presented in a tabular format. The objective is to present a summary of terminal unit performance for an area of the facility. One page is required for each group of terminal units. In the tabular data, do not use less than 12 pt font size. Multiple linked pages may be used if there are a large number of terminals served by one delivery system.
   1) Display in the table:
      a) Process variables.
      b) Set points for each process.
      c) Command to each end device.

d) Status of each end device.
e) Load factors such as terminal load for a VAV terminal unit.
2) Link to the page for each Terminal Unit.
3) Link up to the Delivery System page.
4) Link up to the Floor Plan page.
5) Link up to the Building page.
6) Link up to the Site Plan page.

k. Terminal Unit Page: A graphical representation of a terminal unit such as a VAV terminal or fan coil terminal. One page for each terminal unit.
1) Link up to the Terminal Summary page.
2) Link up to the Floor Plan page.
3) Link up to the Building page.
4) Link up to the Site Plan page.
5) The graphic representation of the equipment shall be 3-dimensional and shall represent the actual installed terminal unit (if the VAV does not have a fan, a fan should not be shown, etc.).
6) Display:
a) Process variables.
b) Command to end devices.
c) Status of end devices.
d) Set points for each process.
e) Modes (auto, heat, cool, etc.).
f) Capacity indicators (terminal load, %heat, %cool, etc.).
g) Reset schedules.
h) Occupancy commands and status.
i) Alarm points.

3. For all points on a graphic page that are subject to being under manual or test mode, the display shall indicate when test mode or manual mode has been applied to the point.
4. Color Graphic Page Requirements:
a. The sequence of control defines the buildings and all of the equipment items for which graphic pages shall be constructed as described above.
b. The BAS provider shall develop similar additional graphic pages to be defined during the construction period as follows:
1) Up to five additional pages per building.
2) Up to twenty additional global pages.

C. User Groups:
1. The BAS provider shall configure four users groups, one for each level of security. The group names shall be representative of the "names" below:
a. BAS Administrators
b. BAS Engineers
c. BAS Operators
d. BAS Viewers

D. Users:
1. The BAS provider shall configure two users in each user group. The names and passwords shall be representative of the "names" below:
a. BAS Administrators Group:
1) Admin1 / Admin1
2) Admin2 / Admin2

b. BAS Engineers Group:
   1) Engr1 / Engr1
   2) Engr2 / Engr2
c. BAS Operators Group:
   1) Oper1 / Oper1
   2) Oper2 / Oper2
d. BAS Viewers Group:
   1) View1 / View1
   2) View2 / View2

2. With the exception of the BAS Viewers Group, these users shall not be added to the system until all testing has been completed and the system has been accepted. The BAS provider shall accept all responsibility for actions that result from the unauthorized issuance of user names and passwords above the level of viewers prior to system acceptance unless specifically instructed to do so in writing by the AOC.

E. BAS Alarm Processing:
1. All alarms required by the sequence of control shall be fully configured for delivery to the operator workstations and the alarm files.
2. A common alarm file shall be established to receive alarms from all of the field devices.
3. A separate alarm file shall be established on a per building basis to receive just the alarms from that building.
4. The alarm messages shall be descriptive and include as a minimum:
   a. System identification
   b. Date
   c. Time to the second
   d. Nature of the alarm such as high value, low value, or fail to start.
5. The system shall be configured to send an alarm message on return to normal.
6. All users shall receive all alarms.

2.30 WEB SERVER

A. The web server shall be configured to present data from all of the field devices.

B. The web server shall be configured to allow 3 concurrent users.

C. The web server shall be configured to require a user name and password for log-in from a web client.

D. The web server shall be configured to allow the web clients to do the following:
1. View all graphic pages that can be viewed from a operator workstation.
2. View historical trend logs
3. Receive and acknowledge alarms
4. Manually control points
5. Initiate generation and view static reports
6. Adjust time schedule parameters

2.31 CONTROL SEQUENCES

A. BAS Control sequences are to be determined by the BAS provider in the design and deployment of BAS.

2.32 CONTROL SYSTEM CHECKOUT, TESTING AND TRAINING

A. The BAS provider shall furnish all labor and test apparatus required to execute the start up testing and owners commissioning plan. Key tasks to be executed and documented in the start-up testing and commissioning verification report include:
   1. Verification of all primary and secondary voltages.
   2. Verification that power wiring for all devices conforms to manufacturer's instructions.
   3. Verification that all labeling is in place.
   4. Verification and Inspection of wiring for loose strands and tight connections.
   5. Verification and Inspection of all BAS control panel electrical grounding
   6. Verification of field bus topology, grounding of shields (if used) and installation of termination devices.
   7. Verification that each I/O device is landed per the submittals and functions per the sequence of control.
      a. Analog sensors shall be properly scaled and a value reported to the OWS.
      b. Binary sensors shall have the specified normal position and the state is reported to the OWS.
      c. Analog outputs have the specified normal position and move full stroke when so commanded.
      d. Binary outputs have the specified normal state and respond to energize / de-energize commands.
   8. Analog sensors have been calibrated with high quality instrumentation suitable for the sensor being calibrated.
      a. The instruments shall display a current (12 month) NIST traceable calibration sticker. Associated instrument calibration certificates shall be made available within 24 hours of a request.
      b. The measured value, reported value, and the calculated offset that was entered into the database shall be recorded.
      c. The calibration criteria shall be:
         1) Space Temperature: +/- 0.4 degrees F
         2) Air Temperature: +/- 0.5 degrees F
         3) Fluid Temperature: +/- 0.6 degrees F
         4) Air Flow Rate: +/- 5 %
         5) Liquid Flow Rate: +/- 5 %
         6) Differential Pressure: +/- 3 %
         7) Gauge Pressure: +/- 5%
         8) Relative Humidity: +/- 3 % relative humidity
         9) CO_2: +/- 2 %
   9. Loop Tuning:
      a. The contractor shall tune all P, PI and PID control loops.
      b. The loop tuning criteria shall be a stable control loop where the average error over 15 minutes and 30 samples shall be less than:
         1) Space Temperature: +/- 0.75 degrees F
         2) Air Temperature: +/- 1.50 degrees F
         3) Air Humidity: +/- 5 % relative humidity
         4) Chilled Water Temp: +/- 1.00 degrees F
         5) Hot Water Temp: +/- 1.00 degrees F
         6) Duct Pressure: +/- 0.2 inches wg.

B. Training:
   1. Coordinate with the requirements of Sections 01 9113 and 01 9114.

2. To be defined by the "Lon" System BAS provider, the AOC representatives, and AOC BAS designated service providers.

C. LEED System Interface:
1. Coordinate communication / interface with the building's interactive LEED Educational Display as required for Credit IDc1.1. Refer to Section 101400 "Signage" for details on the display panel. The BAS provider shall coordinate with the Signage provider to ensure delivery of all BAS system data points and graphics required for integration into the Educational Display.

PART 3 - EXECUTION (Not Used)

END OF SECTION 230900

SECTION 231123 - FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.
5. Pressure regulators.
6. Service meters.
7. Concrete bases.

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, 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.

1.4 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig (690 kPa) minimum unless otherwise indicated.
2. Service Regulators: 100 psig (690 kPa) minimum unless otherwise indicated.
3. Minimum Operating Pressure of Service Meter: 10 psig (69 kPa).

B. Natural-Gas System Pressure within Buildings: More than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa).

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 ACTION 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 bypass fittings and meter bars supports.
6. Dielectric fittings.

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 (1:50) .
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.

1.6 INFORMATIONAL SUBMITTALS

A. 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.

B. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.

C. Qualification Data: For qualified professional engineer.

D. Welding certificates.

E. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For motorized gas valves pressure regulators and service meters to include in emergency, operation, and maintenance manuals.

1.8 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.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.9 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.

1.10 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 Construction Manager no fewer than two days in advance of proposed interruption of natural-gas service.
2. Do not proceed with interruption of natural-gas service without Construction Manager's written permission.

1.11 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. Comply with requirements in Section 083113 "Access Doors and Frames."

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.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
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:

    a. Material Group: 1.1.
    b. End Connections: Threaded or butt welding to match pipe.
    c. Lapped Face: Not permitted underground.
    d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
    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.

6. Mechanical Couplings:

    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

        1) Dresser Piping Specialties.
        2) Smith-Blair, Inc.
        3) Victaulic Company.

    b. Stainless-steel flanges and tube with epoxy finish.
    c. Buna-nitrile seals.
    d. Stainless-steel bolts, washers, and nuts.
    e. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
    f. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig (3.45 kPa).
6. End Fittings: Zinc-coated steel.
7. Threaded Ends: Comply with ASME B1.20.1.
8. Maximum Length: 72 inches (1830 mm.)

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.

1. Copper-alloy convenience outlet and matching plug connector.
2. Nitrile seals.
3. Hand operated with automatic shutoff when disconnected.
4. For indoor or outdoor applications.
5. Adjustable, retractable restraining cable.

C. 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 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (862 kPa).

D. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (862 kPa).

E. 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.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F (540 deg C) complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

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 (DN 50) and Smaller: Comply with ASME B16.33.

1. CWP Rating: 125 psig (862 kPa) .
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch (25 mm) and smaller.
6. Service Mark: Valves 1-1/4 inches (32 mm) to NPS 2 (DN 50) shall have initials "WOG" permanently marked on valve body.

C. General Requirements for Metallic Valves, NPS 2-1/2 (DN 65) and Larger: Comply with ASME B16.38.

1. CWP Rating: 125 psig (862 kPa) .
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. A.Y. McDonald Mfg. Co.
    b. BrassCraft Manufacturing Co.; a Masco company.
    c. Conbraco Industries, Inc.
    d. Perfection Corporation.
2. Body: Bronze, complying with ASTM B 584.
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.
7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
8. CWP Rating: 600 psig (4140 kPa).

9. Listing: Valves NPS 1 (DN 25) 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. A.Y. McDonald Mfg. Co.
    b. Lee Brass Company.
2. Body: Bronze, complying with ASTM B 584.
3. Plug: Bronze.
4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig (862 kPa).
7. Listing: Valves NPS 1 (DN 25) 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. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. A.Y. McDonald Mfg. Co.
    b. Mueller Co.
    c. Xomox Corporation.
2. Body: Cast iron, complying with ASTM A 126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
6. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig (862 kPa).
9. Listing: Valves NPS 1 (DN 25) 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.

G. Cast-Iron, Lubricated Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. A.Y. McDonald Mfg. Co.
    b. Flowserve Corporation.
    c. Homestead Valve.
    d. Milliken Valve Company.

e. Mueller Co.

2. Body: Cast iron, complying with ASTM A 126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
6. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig (862 kPa).
9. Listing: Valves NPS 1 (DN 25) 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.

H. 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.
b. Lyall, R. W. & Company, Inc.
c. Perfection Corporation.

2. Body: PE.
3. Ball: PE.
4. Stem: Acetal.
5. Seats and Seals: Nitrile.
6. Ends: Plain or fusible to match piping.
7. CWP Rating: 80 psig (552 kPa) .
8. Operating Temperature: Minus 20 to plus 140 deg F (Minus 29 to plus 60 deg C) .
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.

I. 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 (125 mm) 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.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Pacific Seismic Products, Inc.

2. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
3. Maximum Operating Pressure: 7 psig (48 kPa) .
4. Cast-aluminum body with stainless-steel internal parts.
5. Nitrile-rubber, reset-stem o-ring seal.
6. Valve position, open or closed, indicator.
7. Composition valve seat with clapper held by spring or magnet locking mechanism.
8. Level indicator.
9. End Connections: Threaded for valves NPS 2 (DN 50) and smaller; flanged for valves NPS 2-1/2 (DN 65) and larger.

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 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) 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. Invensys.
   d. Richards Industries.
2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
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.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 100 psig (690 kPa) .

C. Line 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 & Instruments; a brand of Emerson Process Management.
d. Invensys.
e. Richards Industries.

2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
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.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 5 psig (34.5 kPa) .

D. Appliance Pressure Regulators: Comply with ANSI Z21.18.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Canadian Meter Company Inc.
b. Eaton.
c. Harper Wyman Co.
d. Maxitrol Company.
e. SCP, Inc.

2. Body and Diaphragm Case: Die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
9. Maximum Inlet Pressure: 2 psig (13.8 kPa) .

2.7 SERVICE METERS

A. Diaphragm-Type Service Meters: Comply with ANSI B109.2.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Actaris.
b. American Meter Company.

c. Invensys.
d. Itron Gas.

2. Case: Die-cast aluminum.
3. Connections: Steel threads.
4. Diaphragm: Synthetic fabric.
5. Diaphragm Support Bearings: Self-lubricating.
6. Compensation: Continuous temperature and pressure.
7. Meter Index: Cubic feet .
8. Meter Case and Index: Tamper resistant.
9. Remote meter reader compatible.
10. Maximum Inlet Pressure: 100 psig (690 kPa) .
11. Pressure Loss: Maximum 2.0-inch wg (498 Pa) .
12. Accuracy: Maximum plus or minus 1.0 percent.

B. Service-Meter Bars:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. A.Y. McDonald Mfg. Co.
b. Actaris.
c. American Meter Company.
d. Itron Gas.
e. Lyall, R. W. & Company, Inc.

2. Malleable- or cast-iron frame for supporting service meter.
3. Include offset swivel pipes, meter nuts with o-ring seal, and factory- or field-installed dielectric unions.
4. Omit meter offset swivel pipes if service-meter bar dimensions match service-meter connections.

C. Service-Meter Bypass Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Lyall, R. W. & Company, Inc.
b. Williamson, T. D., Inc.

2. Ferrous, tee, pipe fitting with capped side inlet for temporary natural-gas supply.
3. Integral ball-check bypass valve.

2.8 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. A.Y. McDonald Mfg. Co.
b. HART Industrial Unions, LLC.
c. Matco-Norca.
d. Wilkins.
e. Zurn Industries, LLC.

2. Description:

a. Standard: ASSE 1079.
b. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C) .
c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Capitol Manufacturing Company.
b. Matco-Norca.
c. Watts; a Watts Water Technologies company.
d. Wilkins.

2. Description:

a. Standard: ASSE 1079.
b. Factory-fabricated, bolted, companion-flange assembly.
c. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C) .
d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Pipeline Seal and Insulator, Inc.

2. Description:

a. Nonconducting materials for field assembly of companion flanges.
b. Pressure Rating: 150 psig (1035 kPa) .
c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
e. Washers: Phenolic with steel backing washers.

2.9 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 (150 mm) wide and 4 mils (0.1 mm) 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 (750 mm) 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 36 inches (900 mm) below finished grade. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

1. If natural-gas piping is installed less than 36 inches (900 mm) below finished grade, install it in containment conduit.

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. Copper Tubing with Protective Coating:

1. Apply joint cover kits over tubing to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.

F. Install fittings for changes in direction and branch connections.

G. Install pressure gage upstream and downstream from each service regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

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. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. 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 (75 mm) long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

O. 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.

P. 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 (38 mm) 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.

Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

R. Connect branch piping from top or side of horizontal piping.

S. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

T. Do not use natural-gas piping as grounding electrode.

U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

V. Install pressure gage upstream and downstream from each line regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

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 in Section 055000 "Metal Fabrications" for pipe bollards.

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:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
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. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

G. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

H. 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 seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

C. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches (2438 mm); minimum rod size, 3/8 inch (10 mm).
2. NPS 1-1/4 (DN 32): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).

4. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Maximum span, 10 feet (3 m); minimum rod size, 1/2 inch (13 mm).
5. NPS 4 (DN 100) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 5/8 inch (15.8 mm).

D. Install hangers for horizontal drawn-temper copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 3/8 (DN 10): Maximum span, 48 inches (1220 mm); minimum rod size, 3/8 inch (10 mm).
2. NPS 1/2 and NPS 5/8 (DN 15 and DN 18): Maximum span, 72 inches (1830 mm); minimum rod size, 3/8 inch (10 mm).
3. NPS 3/4 and NPS 7/8 (DN 20 and DN 22): Maximum span, 84 inches (2134 mm); minimum rod size, 3/8 inch (10 mm).
4. NPS 1 (DN 25): Maximum span, 96 inches (2440 mm); minimum rod size, 3/8 inch (10 mm).

E. Install hangers for horizontal, corrugated stainless-steel tubing with the following maximum spacing and minimum rod sizes:

1. NPS 3/8 (DN 10): Maximum span, 48 inches (1220 mm); minimum rod size, 3/8 inch (10 mm).
2. NPS 1/2 (DN 15): Maximum span, 72 inches (1830 mm); minimum rod size, 3/8 inch (10 mm).
3. NPS 3/4 (DN 20) and Larger: Maximum span, 96 inches (2440 mm); minimum rod size, 3/8 inch (10 mm).

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 (1800 mm) 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 in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.11 PAINTING

A. Comply with requirements in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting" 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.

    a. Prime Coat: Alkyd anticorrosive metal primer.
    b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
    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.

D. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.12 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Use 3000-psig (20.7-MPa) , 28-day, compressive-strength concrete and reinforcement as specified in Section 033000 "Cast-in-Place Concrete." orSection 033053 "Miscellaneous Cast-in-Place Concrete."

3.13 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Test, inspect, and purge natural gas according to NFPA 54 and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.14 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain earthquake valves.

3.15 OUTDOOR PIPING SCHEDULE

A. Underground natural-gas piping shall be the following:
1. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.

B. Aboveground natural-gas piping shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.

C. Branch Piping in Cast-in-Place Concrete to Single Appliance: Annealed-temper copper tube with wrought-copper fittings and brazed joints. Install piping embedded in concrete with no joints in concrete.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.16 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG (3.45 kPa)

A. Aboveground, branch piping NPS 1 (DN 25) and smaller shall be the following:

1. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.

B. Aboveground, distribution piping shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Drawn-temper copper tube with wrought-copper fittings and brazed joints.

C. Underground, below building, piping shall be the following:
1. Steel pipe with wrought-steel fittings and welded joints.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.17 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG (3.45 kPa) AND LESS THAN 5 PSIG (34.5 kPa)

A. Aboveground, branch piping NPS 1 (DN 25) and smaller shall be the following:

1. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.

B. Aboveground, distribution piping shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.

C. Underground, below building, piping shall be the following:
1. Steel pipe with wrought-steel fittings and welded joints.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat underground pipe and fittings with protective coating for steel piping.

E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.18 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 (DN 50) and Smaller: Bronze plug valves.
3. NPS 2-1/2 (DN 65) and Larger: Cast-iron, nonlubricated plug valves.

3.19 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 (DN 50) 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 (DN 65) and larger at service meter shall be the following:

1. Two-piece, full -port, bronze ball valves with bronze trim.
2. Bronze plug valve.
3. Cast-iron, nonlubricated plug valve.

C. Distribution piping valves for pipe sizes NPS 2 (DN 50) 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 (DN 65) and larger shall be one of the following:

   1. Two-piece, full -port, bronze ball valves with bronze trim.
   2. Bronze plug valve.
   3. Cast-iron, nonlubricated 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 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

1.2 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig.
2. Suction Lines for Heat-Pump Applications: 535 psig.
3. Hot-Gas and Liquid Lines: 535 psig.

1.3 ACTION 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: 1/8 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.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.7 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.

1.8 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

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:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
4. Pressure Rating: Factory test at minimum 500 psig.

5. Maximum Operating Temperature: 250 deg F.

2.2 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: 500 psig.
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.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig.
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.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig.
8. Working Pressure Rating: 500 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.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.

3. Seat: Polytetrafluoroethylene.
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 24-V ac coil.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg F.
8. Manual operator.

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.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig.
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.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 deg F.
6. Superheat: Adjustable.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: 700 psig or 450 psig as required.

H. Straight-Type Strainers:

1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

I. 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.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

J. Moisture/Liquid Indicators:

1. Body: Forged brass.

2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 240 deg F.

K. 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. Desiccant Media: Activated alumina or charcoal.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Rated Flow: Coordinate.
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 240 deg F.

L. Mufflers:

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

M. 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.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

N. Liquid Accumulators: Comply with ARI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

2.3 REFRIGERANTS

A. 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 equal.

B. 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 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. Refer to Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. 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 in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. 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.

P. 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.

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 according to Section 230553 "Identification for HVAC Piping and Equipment."

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

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. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

D. 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.

E. 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.

F. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

G. Welded Joints: Construct joints according to AWS D10.12/D10.12M.

H. 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 specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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.

D. 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 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Double-wall rectangular ducts and fittings.
3. Single-wall round and flat-oval ducts and fittings.
4. Double-wall round and flat-oval ducts and fittings.
5. Sheet metal materials.
6. Duct liner.
7. Sealants and gaskets.
8. Hangers and supports.
9. Seismic-restraint devices.

B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233116 "Nonmetal Ducts" for fibrous-glass ducts, thermoset fiber-reinforced plastic ducts, thermoplastic ducts, PVC ducts, and concrete ducts.
3. Section 233119 "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
4. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," ASCE/SEI 7 and SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

1. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.
2. See Section 230548 for additional information.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
3. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1, Section 6.4.4.2.2 - "Duct Leakage Tests."
4. Duct-Cleaning Test Report for Prerequisite IEQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-up."
5. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
6. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

D. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.

5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Perimeter moldings.

B. Welding certificates.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports, AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports, and AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

E. Mockups:

1. Before installing duct systems, build mockups representing static-pressure classes in excess of 3-inch wg. Build mockups to comply with the following requirements, using materials indicated for the completed Work:

    a. Five transverse joints.
    b. One access door.
    c. Two typical branch connections, each with at least one elbow.
    d. Two typical flexible duct or flexible-connector connections for each duct and apparatus.
    e. One 90-degree turn with turning vanes.
    f. One fire damper.
    g. Perform leakage tests specified in "Field Quality Control" Article. Revise mockup construction and perform additional tests as required to achieve specified minimum acceptable results.

2. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. McGill AirFlow LLC.
2. Sheet Metal Connectors, Inc.
3. Or approved equal.

B. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

F. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.
4. Cover insulation with polyester film complying with UL 181, Class 1.

G. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23 percent.

H. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Traverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

I. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Lindab Inc.
b. McGill AirFlow LLC.
c. SEMCO Incorporated.
d. Sheet Metal Connectors, Inc.
e. Spiral Manufacturing Co., Inc.
f. Or approved equal.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 DOUBLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Lindab Inc.

2. McGill AirFlow LLC.
3. SEMCO Incorporated.
4. Sheet Metal Connectors, Inc.
5. Or approved equal.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.

1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

   a. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

   a. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
   b. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23 percent.

E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.
4. Cover insulation with polyester film complying with UL 181, Class 1.

2.5 SHEET METAL MATERIALS

A. General Material Requirements: 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: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60 or G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

E. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

F. Factory- or Shop-Applied Antimicrobial Coating:

1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
5. Shop-Applied Coating Color: Black or White.
6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

G. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

H. 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.

2.6 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. CertainTeed Corporation; Insulation Group.
    b. Johns Manville.
    c. Knauf Insulation.
    d. Owens Corning.
    e. Or approved equal.

2. Maximum Thermal Conductivity:

    a. Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
    b. Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

3. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
4. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

    a. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
    b. Adhesive 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. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. 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.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.

6. 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.
7. 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:

    a. Fan discharges.
    b. Intervals of lined duct preceding unlined duct.
    c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

8. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.

    a. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.

9. 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.

2.7 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 3 inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
11. 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."

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
9. VOC: Maximum 395 g/L.
10. 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."
11. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
12. Service: Indoor or outdoor.
13. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. 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."

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.8 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.9 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper B-Line, Inc.; a division of Cooper Industries.
2. Ductmate Industries, Inc.
3. Hilti Corp.
4. Kinetics Noise Control.
5. Loos & Co.; Cableware Division.
6. Mason Industries.
7. TOLCO; a brand of NIBCO INC.
8. Unistrut Corporation; Tyco International, Ltd.
9. Or approved equal.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service, the Office of Statewide Health Planning and Development for the State of California, 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: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

D. Restraint Cables: ASTM A 603, galvanized-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round and flat-oval ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

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. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.

6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems," ASCE/SEI 7.

1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
2. Brace a change of direction longer than 12 feet.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service, the Office of Statewide Health Planning and Development for the State of California, an agency acceptable to authorities having jurisdiction.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect 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. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.6 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:

a. Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections, selected by Architect from sections installed, totaling no less than 25 percent of total installed duct area for each designated pressure class.
b. Supply Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
c. Return Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
d. Exhaust Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.9 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.10 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.11 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel.

1. Underground Ducts Located in a Concrete Vault Enclosure: Concrete-encased, galvanized sheet steel.
2. See the following Duct Schedule for additional information.

B. Supply Ducts:

1. Ducts Connected to Fan Coil Units and Terminal Units:

   a. Pressure Class: Positive 2-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 6.
   d. SMACNA Leakage Class for Round and Flat Oval: 3.
   e. Duct Liner: Fibrous glass, Type I, 1 inch thick.

2. Ducts Connected to Constant-Volume Air-Handling Units:

   a. Pressure Class: Positive 3-inch wg.
   b. Minimum SMACNA Seal Class: A
   c. SMACNA Leakage Class for Rectangular: 6.
   d. SMACNA Leakage Class for Round and Flat Oval: 3.
   e. Duct Liner: Fibrous glass, Type I, 1 inch thick.

3. Ducts Connected to Variable-Air-Volume Air-Handling Units:

   a. Pressure Class: Positive 4-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 3.
   d. SMACNA Leakage Class for Round and Flat Oval: 3.
   e. Duct Liner: None.

4. Ducts Connected to Variable-Air-Volume Air Handling Units - Double Wall - Located in Penthouse and Vertical Chases:

    a. Pressure Class: Positive 4-inch wg.
    b. Minimum SMACNA Seal Class: A.
    c. SMACNA Leakage Class for Rectangular: 3.
    d. SMACNA Leakage Class for Round and Flat Oval: 3.
    e. Double-Wall Duct Interstitial Insulation: Supply Air Ducts: 2 inches thick.

C. Return Ducts:

1. Ducts Connected to Fan Coil Units:

    a. Pressure Class: Positive or negative 2-inch wg.
    b. Minimum SMACNA Seal Class: A.
    c. SMACNA Leakage Class for Rectangular: 6.
    d. SMACNA Leakage Class for Round and Flat Oval: 6.
    e. Duct Liner: 1 inch thick.

2. Ducts Connected to Constant-Volume and Variable-Volume Air-Handling Units:

    a. Pressure Class: Positive or negative 2-inch wg.
    b. Minimum SMACNA Seal Class: A.
    c. SMACNA Leakage Class for Rectangular: 6.
    d. SMACNA Leakage Class for Round and Flat Oval: 3.
    e. Duct Liner: 1 inch thick.

3. Ducts Connected to Variable-Air-Volume Air Handling Units - Double Wall - Located in Penthouse and Vertical Chases:

    a. Pressure Class: Positive or negative 2-inch wg.
    b. Minimum SMACNA Seal Class: A.
    c. SMACNA Leakage Class for Rectangular: 6.
    d. SMACNA Leakage Class for Round and Flat Oval: 3.
    e. Double-Wall Duct Interstitial Insulation: 2 inches thick.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

    a. Pressure Class: Negative 2-inch wg.
    b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
    c. SMACNA Leakage Class for Rectangular: 6.
    d. SMACNA Leakage Class for Round and Flat Oval: 3.
    e. Duct Liner: None.

2. Ducts Connected to Air-Handling Units (All):

    a. Pressure Class: Positive or negative 2-inch wg.

b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: 6.
d. SMACNA Leakage Class for Round and Flat Oval: 3.
e. Duct Liner: None.

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Fan Coil Units:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 6.
d. SMACNA Leakage Class for Round and Flat Oval: 3.
e. Duct Liner: None.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 6.
d. SMACNA Leakage Class for Round and Flat Oval: 3.
e. Duct Liner: None.

3. Transfer Air Ducts Not Listed Above:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 6.
d. SMACNA Leakage Class for Round and Flat Oval: 3.
e. Duct Liner: 1 inch thick.

F. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.
2. PVC-Coated Ducts:

a. Exposed to Airstream: Match duct material.
b. Not Exposed to Airstream: Galvanized or match duct material.

3. Stainless-Steel Ducts:

a. Exposed to Airstream: Match duct material.
b. Not Exposed to Airstream: Galvanized or match duct material.

4. Aluminum Ducts: Galvanized sheet steel coated with zinc chromate.

G. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

    a. Velocity 1000 fpm or Lower:

        1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
        2) Mitered Type RE 4 without vanes.

    b. Velocity 1000 to 1500 fpm:

        1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
        2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
        3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

    c. Velocity 1500 fpm or Higher:

        1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
        2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
        3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

    a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
    b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
    c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

    a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

        1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
        2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
        3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.

    b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.

c. Round Elbows, 14 Inchesand Larger in Diameter: Welded.

H. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

   a. Velocity 1000 fpm or Lower: 90-degree tap.
   b. Velocity 1000 to 1500 fpm: Conical tap.
   c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Barometric relief dampers.
3. Manual volume dampers.
4. Fire dampers.
5. Ceiling radiation dampers.
6. Smoke dampers.
7. Combination fire and smoke dampers.
8. Corridor dampers.
9. Flange connectors.
10. Duct silencers.
11. Turning vanes.
12. Remote damper operators.
13. Duct-mounted access doors.
14. Flexible connectors.
15. Flexible ducts.
16. Duct security bars.
17. Duct accessory hardware.

B. Related Requirements:

1. Section 233723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
2. Division 28 Section Fire-Alarm System for duct-mounted fire and smoke detectors.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data for Prerequisite EA 2: Documentation indicating that duct insulation R-values comply with tables in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air Conditioning."

C. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

    a. Special fittings.
    b. Manual volume damper installations.
    c. Control-damper installations.
    d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
    e. Duct security bars.
    f. Wiring Diagrams: For power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

B. Source quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. 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.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60 or G90.
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and exposed finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. American Warming and Ventilating; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Greenheck Fan Corporation.
5. Lloyd Industries, Inc.
6. Nailor Industries Inc.
7. NCA Manufacturing, Inc.
8. Pottorff.
9. Ruskin Company.
10. Vent Products Company, Inc.
11. Or approved equal.

B. Description: Gravity balanced.

C. Maximum Air Velocity: 3000 fpm.

D. Maximum System Pressure: 3-inch wg.

E. Frame: Hat-shaped, 0.05-inch-thick, galvanized sheet steel, with welded corners or mechanically attached and mounting flange.

F. Blades: Multiple single-piece blades, off-center pivoted, or end pivoted, maximum 6-inch width, 0.050-inch-thick aluminum sheet with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Neoprene, mechanically locked.

I. Blade Axles:

1. Material: Galvanized steel.
2. Diameter: 0.20 inch.

J. Tie Bars and Brackets: Galvanized steel.

K. Return Spring: Adjustable tension.

L. Bearings: Steel ball.

M. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. 90-degree stops.

2.4 BAROMETRIC RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. American Warming and Ventilating; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Greenheck Fan Corporation.
5. Lloyd Industries, Inc.
6. Nailor Industries Inc.
7. NCA Manufacturing, Inc.
8. Pottorff.
9. Ruskin Company.
10. Vent Products Company, Inc.
11. Or approved equal.

B. Suitable for horizontal or vertical mounting.

C. Maximum Air Velocity: 2500 fpm.

D. Maximum System Pressure: 3-inch wg.

E. Frame: Hat-shaped, 0.063-inch-thick extruded aluminum, with welded corners or mechanically attached and mounting flange.

F. Blades:

1. Multiple, 0.025-inch-thick, roll-formed aluminum.
2. Maximum Width: 6 inches.
3. Action: Parallel.
4. Balance: Gravity.

5. Eccentrically pivoted.

G. Blade Seals: Neoprene.

H. Blade Axles: Galvanized steel.

I. Tie Bars and Brackets:

1. Material: Aluminum.
2. Rattle free with 90-degree stop.

J. Return Spring: Adjustable tension.

K. Bearings: Stainless steel.

L. Accessories:

1. Flange on intake.
2. Adjustment device to permit setting for varying differential static pressures.

2.5 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Air Balance Inc.; a division of Mestek, Inc.
b. American Warming and Ventilating; a division of Mestek, Inc.
c. Flexmaster U.S.A., Inc.
d. McGill AirFlow LLC.
e. Nailor Industries Inc.
f. Pottorff.
g. Ruskin Company.
h. Trox USA Inc.
i. Vent Products Company, Inc.
j. Or approved equal.

2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames:

a. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel.
b. Mitered and welded corners.
c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

a. Multiple or single blade.
b. Parallel- or opposed-blade design.
c. Stiffen damper blades for stability.

d. Galvanized-steel, 0.064 inch thick.

6. Blade Axles: Galvanized steel.
7. Bearings:

a. Oil-impregnated bronze.
b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Air Balance Inc.; a division of Mestek, Inc.
b. American Warming and Ventilating; a division of Mestek, Inc.
c. McGill AirFlow LLC.
d. Nailor Industries Inc.
e. Pottorff.
f. Ruskin Company.
g. Trox USA Inc.
h. Vent Products Company, Inc.
i. Or approved equal.

2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames: Hat-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:

a. Multiple or single blade.
b. Parallel- or opposed-blade design.
c. Stiffen damper blades for stability.
d. Roll-Formed Aluminum Blades: 0.10-inch-thick aluminum sheet.
e. Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.

6. Blade Axles: Galvanized steel.
7. Bearings:

a. Oil-impregnated bronze.
b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Aluminum.

C. Low-Leakage, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Air Balance Inc.; a division of Mestek, Inc.
b. American Warming and Ventilating; a division of Mestek, Inc.
c. McGill AirFlow LLC.
d. Nailor Industries Inc.
e. Pottorff.
f. Ruskin Company.
g. Trox USA Inc.
h. Vent Products Company, Inc.
i. Or approved equal.

2. Comply with AMCA 500-D testing for damper rating.
3. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
4. Suitable for horizontal or vertical applications.
5. Frames:

a. Hat or U Angle shaped.
b. 0.094-inch-thick, galvanized sheet steel.
c. Mitered and welded corners.
d. Flanges for attaching to walls and flangeless frames for installing in ducts.

6. Blades:

a. Multiple or single blade.
b. Parallel- or opposed-blade design.
c. Stiffen damper blades for stability.
d. Galvanized, roll-formed steel, 0.064 inch thick.

7. Blade Axles: Galvanized steel.
8. Bearings:

a. Oil-impregnated bronze.
b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

9. Blade Seals: Neoprene.
10. Jamb Seals: Cambered stainless steel.
11. Tie Bars and Brackets: Galvanized steel.
12. Accessories:

a. Include locking device to hold single-blade dampers in a fixed position without vibration.

D. Low-Leakage, Aluminum, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Air Balance Inc.; a division of Mestek, Inc.
b. American Warming and Ventilating; a division of Mestek, Inc.
c. McGill AirFlow LLC.
d. Nailor Industries Inc.

e. Pottorff.
f. Ruskin Company.
g. Trox USA Inc.
h. Vent Products Company, Inc.
i. Or approved equal.

2. Comply with AMCA 500-D testing for damper rating.
3. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
4. Suitable for horizontal or vertical applications.
5. Frames: Hat or U Angle-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
6. Blades:

a. Multiple or single blade.
b. Parallel- or opposed-blade design.
c. Roll-Formed Aluminum Blades: 0.10-inch-thick aluminum sheet.
d. Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.

7. Blade Axles: Galvanized steel.
8. Bearings:

a. Oil-impregnated bronze.
b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

9. Blade Seals: Neoprene.
10. Jamb Seals: Cambered aluminum.
11. Tie Bars and Brackets: Aluminum.
12. Accessories:

a. Include locking device to hold single-blade dampers in a fixed position without vibration.

E. Jackshaft:

1. Size: 1-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

F. Damper Hardware:

1. 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.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.6 CONTROL DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. American Warming and Ventilating; a division of Mestek, Inc.
2. Arrow United Industries; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Greenheck Fan Corporation.
5. Lloyd Industries, Inc.
6. McGill AirFlow LLC.
7. Metal Form Manufacturing, Inc.
8. Nailor Industries Inc.
9. NCA Manufacturing, Inc.
10. Pottorff.
11. Ruskin Company.
12. Vent Products Company, Inc.
13. Young Regulator Company.
14. Or approved equal.

B. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

C. Frames:

1. Hat or U Angle shaped.
2. 0.094-inch-thick, galvanized sheet steel.
3. Mitered and welded or interlocking, gusseted corners.

D. Blades:

1. Multiple blade with maximum blade width of 6 inches.
2. Parallel- and opposed-blade design.
3. Galvanized-steel or aluminum.
4. 0.064 inch thick single skin or 0.0747-inch-thick dual skin.
5. Blade Edging: Closed-cell neoprene.
6. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.

E. Blade Axles: 1/2-inch-diameter; stainless steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.

1. Operating Temperature Range: From minus 40 to plus 200 deg F.

F. Bearings:

1. Oil-impregnated stainless-steel sleeve.
2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
3. Thrust bearings at each end of every blade.

2.7 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. Arrow United Industries; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Greenheck Fan Corporation.
5. Nailor Industries Inc.
6. NCA Manufacturing, Inc.
7. Pottorff.
8. Prefco; Perfect Air Control, Inc.
9. Ruskin Company.
10. Vent Products Company, Inc.
11. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
12. Or approved equal.

B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 3000-fpm velocity.

D. Fire Rating: 1-1/2 and 3 hours per Code plan.

E. Frame: Curtain type with blades outside airstream or curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.05 thick, as indicated, and of length to suit application.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, 0.024-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

J. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

2.8 CEILING RADIATION DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.

3. Nailor Industries Inc.
4. Pottorff.
5. Prefco; Perfect Air Control, Inc.
6. Ruskin Company.
7. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
8. Or approved equal.

B. General Requirements:

1. Labeled according to UL 555C by an NRTL.
2. Comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory."

C. Frame: Galvanized sheet steel, round or rectangular, style to suit ceiling construction.

D. Blades: Galvanized sheet steel with refractory insulation.

E. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

F. Fire Rating: 1, 2 or 3 hours per Code plan.

2.9 SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Greenheck Fan Corporation.
4. Nailor Industries Inc.
5. Pottorff.
6. Ruskin Company.
7. Or approved equal.

B. General Requirements: Label according to UL 555S by an NRTL.

C. Smoke Detector: Integral, factory wired for single-point connection.

D. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with welded, interlocking, gusseted or mechanically attached corners and mounting flange.

E. Blades: Roll-formed, horizontal, interlocking or overlapping, 0.034-inch-thick, galvanized sheet steel.

F. Leakage: Class I.

G. Rated pressure and velocity to exceed design airflow conditions.

H. Mounting Sleeve: Factory-installed, 0.05-inch-thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

I. Damper Motors: Two-position action.

J. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230900 "Instrumentation and Control for HVAC."
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism. 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.
5. Outdoor Motors and Motors in Outdoor-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.
6. Electrical Connection: 115 V, single phase, 60 Hz, spring return closed, normally closed, power open.

K. Accessories:

1. Auxiliary switches for signaling, fan control or position indication.
2. Momentary test switch, test and reset switches, damper remote mounted.

2.10 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Greenheck Fan Corporation.
4. Nailor Industries Inc.
5. Pottorff.
6. Ruskin Company.
7. Or approved equal.

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 3000-fpm velocity.

D. Fire Rating: 1-1/2 and 3 hours per Code plan.

E. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with welded, interlocking, gusseted or mechanically attached corners and mounting flange.

F. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

G. Smoke Detector: Integral, factory wired for single-point connection.

H. Blades: Roll-formed, horizontal, interlocking, overlapping, 0.063-inch-thick, galvanized sheet steel.

I. Leakage: Class I.

J. Rated pressure and velocity to exceed design airflow conditions.

K. Mounting Sleeve: Factory-installed, 0.05-inch-thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

L. Master control panel for use in dynamic smoke-management systems.

M. Damper Motors: Two-position action.

N. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230900 "Instrumentation and Control for HVAC."
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism. 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.
5. Outdoor Motors and Motors in Outdoor-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.
6. Electrical Connection: 115 V, single phase, 60 Hz, spring return closed, normally closed, power open.

O. Accessories:

1. Auxiliary switches for signaling, fan control or position indication.
2. Momentary test switch, test and reset switches, damper remote mounted.

2.11 CORRIDOR DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Nailor Industries Inc.
4. Pottorff.

5. Ruskin Company.
6. Or approved equal.

B. General Requirements: Label combination fire and smoke dampers according to UL 555 for 1-hour or 1-1/2-hour rating by an NRTL.

C. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

D. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with welded, interlocking, gusseted or mechanically attached corners and mounting flange.

E. Blades: Roll-formed, horizontal, interlocking or overlapping, 0.034-inch-thick, galvanized sheet steel.

F. Mounting Sleeve: Factory-installed, 0.05-inch-thick, galvanized sheet steel; length to suit wall or floor application.

G. Damper Motors: Two-position action.

H. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230900 "Instrumentation and Control for HVAC."
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. 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.
5. Outdoor Motors and Motors in Outdoor-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.
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
7. Electrical Connection: 115 V, single phase, 60 Hz.

2.12 FLANGE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ductmate Industries, Inc.
2. Nexus PDQ; Division of Shilco Holdings Inc.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
4. Or approved equal.

B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.

2.13 DUCT SILENCERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Dynasonics.
2. Industrial Noise Control, Inc.
3. McGill AirFlow LLC.
4. Ruskin Company.
5. Vibro-Acoustics.
6. Or approved equal.

B. General Requirements:

1. Factory fabricated.
2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Shape:

1. Rectangular straight with splitters or baffles.
2. Round straight with center bodies or pods.
3. Rectangular elbow with splitters or baffles.
4. Round elbow with center bodies or pods.
5. Rectangular transitional with splitters or baffles.

D. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G90, galvanized sheet steel, 0.040 inch thick.

E. Round Silencer Outer Casing: ASTM A 653/A 653M, G90, galvanized sheet steel.

1. Sheet Metal Thickness for Units up to 24 Inches in Diameter: 0.034 inch thick.
2. Sheet Metal Thickness for Units 26 through 40 Inches in Diameter: 0.040 inch thick.
3. Sheet Metal Thickness for Units 42 through 52 Inches in Diameter: 0.05 inch thick.
4. Sheet Metal Thickness for Units 54 through 60 Inches in Diameter: 0.064 inch thick.

F. Inner Casing and Baffles: ASTM A 653/A 653M, G90 galvanized sheet metal, 0.034 inch thick, and with 1/8-inch-diameter perforations.

G. Special Construction:

1. Suitable for outdoor use.
2. High transmission loss to achieve STC 45.

H. Connection Sizes: Match connecting ductwork unless otherwise indicated.

I. Principal Sound-Absorbing Mechanism:

1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
2. Dissipative type with fill material.

a. Fill Material: Inert and vermin-proof fibrous material, packed under not less than 15 percent compression.
b. Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.

3. Lining: None.

J. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.

1. Joints: Lock formed and sealed, continuously welded or flanged connections.
2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
3. Reinforcement: Cross or trapeze angles for rigid suspension.

K. Accessories:

1. Integral 1-1/2 or 3-hour fire damper with access door. Access door to be high transmission loss to match silencer.
2. Factory-installed end caps to prevent contamination during shipping.
3. Removable splitters.
4. Airflow measuring devices.

L. Source Quality Control: Test according to ASTM E 477.

1. Testing of mockups to be witnessed by Architect and Owner.
2. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000-fpm face velocity.
3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.

M. Capacities and Characteristics:

1. See Drawings and Schedules.

2.14 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Elgen Manufacturing.
4. METALAIRE, Inc.
5. SEMCO Incorporated.
6. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
7. Or approved equal.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

E. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.15 REMOTE DAMPER OPERATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Pottorff.
2. Ventfabrics, Inc.
3. Young Regulator Company.
4. Or approved equal.

B. Description: Cable system designed for remote manual damper adjustment.

C. Tubing: Aluminum.

D. Cable: Stainless steel.

E. Wall-Box Mounting: Recessed.

F. Wall-Box Cover-Plate Material: Steel.

2.16 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. American Warming and Ventilating; a division of Mestek, Inc.

2. Cesco Products; a division of Mestek, Inc.
3. Ductmate Industries, Inc.
4. Elgen Manufacturing.
5. Flexmaster U.S.A., Inc.
6. Greenheck Fan Corporation.
7. McGill AirFlow LLC.
8. Nailor Industries Inc.
9. Pottorff.
10. Ventfabrics, Inc.
11. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
12. Or approved equal.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

    a. Double wall, rectangular.
    b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
    c. Vision panel.
    d. Hinges and Latches: 1-by-1-inchbutt or piano hinge and cam latches.
    e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:

    a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
    b. Access Doors up to 18 Inches Square: Continuous and two sash locks.
    c. Access Doors up to 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.
    d. Access Doors Larger Than 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.

C. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.
2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Factory set at 3.0- to 8.0-inch wg.
5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: 1-inch-thick, fibrous-glass or polystyrene-foam board.

2.17 DUCT ACCESS PANEL ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ductmate Industries, Inc.
2. Flame Gard, Inc.
3. 3M.
4. Or approved equal.

B. Labeled according to UL 1978 by an NRTL.

C. Panel and Frame: Minimum thickness 0.0428-inch stainless steel.

D. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.

E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

F. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.18 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Elgen Manufacturing.
4. Ventfabrics, Inc.
5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
6. Or approved equal.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 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. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

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.

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd..

2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

2.19 FLEXIBLE DUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Flexmaster U.S.A., Inc.
2. McGill AirFlow LLC.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
4. Or approved equal.

B. Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.

1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 175 deg F.
4. Insulation R-Value: Comply with ASHRAE/IESNA 90.1.

C. Flexible Duct Connectors:

1. 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.
2. Non-Clamp Connectors: Liquid adhesive plus tape.

2.20 DUCT SECURITY BARS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Carnes.
2. KEES, Inc.
3. Lloyd Industries, Inc.
4. Metal Form Manufacturing, Inc.
5. Price Industries.
6. Or approved equal.

B. Description: Factory-fabricated and field-installed duct security bars.

C. Configuration:

1. See plans for security duct security bar ad Division 11 Section Detention Equipment.

2.21 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 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. Install 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 or control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers according to UL listing.

H. Install duct security bars. Construct duct security bars from 0.164-inchsteel sleeve, continuously welded at all joints and 1/2-inch-diameter steel bars, 6 inches o.c. in each direction in center of sleeve. Weld each bar to steel sleeve and each crossing bar. Weld 2-1/2-by-2-1/2-by-1/4-inch steel angle to 4 sides and both ends of sleeve. Connect duct security bars to ducts with flexible connections. Provide 12-by-12-inch hinged access panel with cam lock in duct in each side of sleeve.

I. Connect ducts to duct silencers rigidly.

J. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
1. Upstream and downstream from duct filters.
2. At outdoor-air intakes and mixed-air plenums.

3. At drain pans and seals.
4. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
5. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
6. At each change in direction and at maximum 50-foot spacing.
7. Upstream and downstream from turning vanes.
8. Upstream or downstream from duct silencers.
9. Control devices requiring inspection.
10. Elsewhere as indicated.

K. Install access doors with swing against duct static pressure.

L. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.
3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.

M. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

N. Install flexible connectors to connect ducts to equipment.

O. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

P. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

Q. Connect diffusers or light troffer boots to ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.

R. Connect flexible ducts to metal ducts with adhesive and draw bands.

S. Install duct test holes where required for testing and balancing purposes.

T. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

SECTION 233413 - AXIAL HVAC FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Tubeaxial fans.
2. Vaneaxial fans.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, furnished specialties, and accessories for each fan.
2. Certified fan performance curves with system operating conditions indicated.
3. Certified fan sound-power ratings.
4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
5. Material thickness and finishes, including color charts.
6. Dampers, including housings, linkages, and operators.
7. Fan speed controllers.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. 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.

1.4 INFORMATIONAL SUBMITTALS

A. 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.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For axial fans to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Belts: One set for each belt-driven unit.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. AMCA Compliance:

1. Comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal.
2. Operating Limits: Classify according to AMCA 99.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 TUBEAXIAL FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Greenheck Fan Corporation.
2. Howden Buffalo Inc.
3. Loren Cook Company.

B. Description: Fan wheel and housing, factory-mounted motor with direct drive, an inlet cone section, and accessories.

C. Housings: Aluminum with flanged inlet and outlet connections.

D. Wheel Assemblies: Cast or extruded aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.

E. Accessories:

1. Companion Flanges: Rolled flanges of same material as housing.
2. Inspection Door: Bolted door allowing limited access to internal parts of fan, of same material as housing.

3. Propeller Access Section Door: Short duct section bolted to fan inlet and outlet allowing access to internal parts of fan for inspection and cleaning, of same material as housing.
4. Swingout Construction: Assembly allowing entire fan section to swing out from duct for cleaning and servicing, of same material as housing.
5. Mounting Clips: Horizontal ceiling clips welded to fan housing, of same material as housing.
6. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.
7. Vertical Support: Short duct section with welded brackets bolted to fan housing, of same material as housing.
8. Inlet Screen: Wire-mesh screen on fans not connected to ductwork, of same material as housing.
9. Outlet Screen: Wire-mesh screen on fans not connected to ductwork, of same material as housing.
10. Backdraft Dampers: Butterfly style, for bolting to the discharge of fan or outlet cone, of same material as housing.
11. Shaft Seal: Elastomeric seal and Teflon wear plate, suitable for up to 300 deg F.
12. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
13. Inlet Vanes: Adjustable; with peripheral control linkage operated from outside of airstream, bronze sleeve bearings on each end of vane support, and provision for manual or automatic operation of same material as housing.
14. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.
15. Inlet Cone: Round-to-round transition of same material as housing.
16. Outlet Cone: Round-to-round transition, of same material as housing.
17. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.
18. Direct-Driven Units: Encase motor in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing. Extend lubrication lines to outside of casing and terminate with grease fittings.

F. Factory Finishes:

1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.
3. Coatings: Powder-baked enamel;.

    a. Apply to finished housings.
    b. Apply to fan wheels.

2.3 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/ASHRAE 51, "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install axial fans level and plumb.

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.

D. Equipment Mounting:
1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

E. Install units with clearances for service and maintenance.

F. Label fans according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

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."

3.3 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. 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. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

D. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

D. END OF SECTION 233413

SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Centrifugal roof ventilators.
2. Ceiling-mounted ventilators.
3. In-line centrifugal fans.

1.2 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations.

B. Operating Limits: Classify according to AMCA 99.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also 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.
6. Roof curbs.
7. Fan speed controllers.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For unit hangars and supports 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.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Roof framing and support members relative to duct penetrations.
2. Ceiling suspension assembly members.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power ventilators 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. Belts: One set for each belt-driven 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. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

1.8 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL ROOF VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Acme Engineering & Manufacturing Corporation.
2. Aerovent; a division of Twin City Fan Companies, Ltd.
3. ~~Broan-NuTone LLC.~~
4. ~~4.~~3. Carnes Company.
5. ~~5.~~4. Central Blower Company.
6. ~~6.~~5. Greenheck Fan Corporation.
7. ~~Hartzell Fan Incorporated.~~
8. ~~8.~~6. Loren Cook Company.
9. ~~9.~~7. PennBarry.
10. ~~10.~~8. Or approved equal.

B. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.
2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Belt Drives:

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
5. Fan and motor isolated from exhaust airstream.

E. Accessories:

1. Starter.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted outside fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

F. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Self-flashing without a cant strip, with mounting flange, see plans and details.
2. Overall Height: 12 inches.
3. Sound Curb: Curb with sound-absorbing insulation.
4. Pitch Mounting: Manufacture curb for roof slope.
5. Metal Liner: Galvanized steel.

G. Capacities and Characteristics:

1. See Plans and Schedules.

2.2 CEILING-MOUNTED VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. American Coolair Corporation.
2. Ammerman; Millennium Equipment.
3. Breidert Air Products.
~~4. Broan-NuTone LLC.~~
~~5. Broan-NuTone LLC; NuTone Inc.~~
~~6.~~4. Carnes Company.
~~7.~~5. FloAire.
~~8.~~6. Greenheck Fan Corporation.
~~9. JencoFan.~~
~~10.~~7. Loren Cook Company.
~~11.~~8. PennBarry.
~~12. W.W. Grainger, Inc.; Dayton Products.~~
~~13.~~9. Or approved equal.

B. Housing: Steel, lined with acoustical insulation.

C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

D. Grille: Stainless steel, aluminum or painted aluminum, louvered grille with flange on intake and thumbscrew attachment to fan housing.

E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

F. Accessories: ~~(See plan and Schedule).~~

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Isolation: Rubber-in-shear vibration isolators.
3. Manufacturer's standard roof jack or wall cap, and transition fittings.

G. Capacities and Characteristics:

1. See plans and Schedule.

2.3 IN-LINE CENTRIFUGAL FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Acme Engineering & Manufacturing Corporation.
2. American Coolair Corporation.
3. Greenheck Fan Corporation.
4. Hartzell Fan Incorporated.
5. Loren Cook Company.
6. PennBarry.
7. Or approved equal.

B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.

D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

F. Accessories: (See plan and Schedule.)

1. Companion Flanges: For inlet and outlet duct connections.
2. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
3. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

G. Capacities and Characteristics:

1. See Drawings and Schedules.

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

B. Enclosure Type: Totally enclosed, fan cooled.

2.5 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to 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. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Equipment Mounting:

1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

C. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Section 077200 "Roof Accessories" for installation of roof curbs.

D. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

E. Support suspended units from structure using threaded steel rods and spring hangers with vertical-limit stops. Vibration-control devices are specified in Section 230548 "Vibration and Seismic Controls for HVAC."

F. Install units with clearances for service and maintenance.

G. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. 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.

B. Tests and Inspections:

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. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION 233423

SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Diffusers, grilles and registers as scheduled on the plans. Scheduled models by reference include required features and performance in addition to those specified herein. Where in conflict with this specification section the scheduled products will govern.

B. Related Sections:

1. Division 08 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
2. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.
3. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

1.2 ACTION SUBMITTALS

A. Product Data: For each type of 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. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.

C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

D. Samples and Data for Verification of Seismic mounting and support.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using 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.

B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 CEILING LINEAR SLOT OUTLETS

A. Linear Bar Diffuser:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers:

   a. Air Research Diffuser Products, Inc.
   b. Anemostat Products; a Mestek company.
   c. Krueger.
   d. Nailor Industries Inc.
   e. Price Industries.
   f. Titus.
   g. Tuttle & Bailey.
   h. Or approved equal

2. Devices shall be specifically designed for variable-air-volume flows.
3. Construction and configuration as Scheduled.

2.2 HIGH-CAPACITY DIFFUSERS

A. Modular Core Supply Grilles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers:
   a. Krueger.
   b. Price Industries.
   c. Titus.
   d. Or approved equal

2. Devices shall be specifically designed for variable-air-volume flows.
3. Construction and configuration as Scheduled.

2.3 REGISTERS AND GRILLES

A. Adjustable Bar Register:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers:
   a. Krueger.

b. Price Industries.
c. Titus.
d. Or approved equal

2. Devices shall be specifically designed for variable-air-volume flows.
3. Construction and configuration as Scheduled.

B. Adjustable Bar Grille:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers:
   a. Krueger.
   b. Price Industries.
   c. Titus.
   d. Or approved equal

2. Devices shall be specifically designed for variable-air-volume flows.
3. Construction and configuration as Scheduled.

2.4 SECURITY REGISTERS & GRILLES

A. Security Registers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Krueger.
   b. Price Industries.
   c. Titus.

2. Security Level: Medium and suicide deterrent.
3. Material: Steel.
4. Material Thickness: 0.19 inch.
5. Finish: Baked enamel, color selected by Architect.
6. Face Arrangement:

   a. Shape: Square.
   b. Design: Perforated.
   c. Core: Louvered.
   d. 3/16-inch-thick, perforated faceplate with 3/16-inch-diameter holes spaced 7/16 inch o.c., staggered at 60 degrees.

7. Damper Operation: None.

B. Security Grille:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Krueger.

b. Price Industries.
c. Titus.

2. Security Level: Medium and suicide deterrent.
3. Material: Steel.
4. Material Thickness: 0.19 inch.
5. Finish: Baked enamel, color selected by Architect.
6. Face Arrangement:

a. Shape: Rectangular.
b. Design: Fixed bar.
c. Core: None.
d. 1-1/2-inch bars and mandrel tubes and rods with 15-degree deflection in 1-1/4-by-1-1/4-by-3/16-inch angle border.

7. Mounting: 1-1/4-by-1-1/4-by-3/16-inch cast-in-place frame and tamperproof machine screws.

2.5 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.

~~B.~~C. Provide stainless steel grilles at all shower locations.

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 practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect 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 233723 - HVAC GRAVITY VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Louvered-penthouse ventilators.
2. Roof hoods.

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design ventilators, including comprehensive engineering analysis by a qualified professional engineer, using structural and seismic performance requirements and design criteria indicated.

B. Structural Performance: Ventilators shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of ventilator components, noise or metal fatigue caused by ventilator blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.

1. Wind Loads: Determine loads based on a uniform pressure of 30 lbf/sq. ft., acting inward or outward.

C. Seismic Performance: Ventilators, including attachments to other construction, 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."

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes, without buckling, opening of joints, overstressing of components, failure of connections, or other detrimental effects.

1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

E. Water Entrainment: Limit water penetration through unit to comply with ASHRAE 62.1.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. For louvered-penthouse ventilators specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.

~~B. LEED Submittals:~~

~~1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."~~

~~C.~~B. Shop Drawings: For gravity ventilators. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.

1. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.

~~D.~~C. Samples: For each exposed product and for each color and texture specified.

~~E.~~D. Samples for Initial Selection: For units with factory-applied color finishes.

~~F.~~E. Samples for Verification: For each type of louvered-penthouse ventilator indicated, in manufacturer's standard size.

~~G.~~F. Delegated-Design Submittal: For shop-fabricated ventilators 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 shop-fabricated ventilators.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Roof framing plans and other details, 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 roof curbs and ventilators will be attached.
2. Sizes and locations of roof openings.

B. Seismic Qualification Certificates: For ventilators, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."

2. AWS D1.3, "Structural Welding Code - Sheet Steel."

1.6 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Aluminum Extrusions: ASTM B 221, Alloy 6063-T5 or T-52.

B. Aluminum Sheet: ASTM B 209, Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.

C. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 zinc coating, mill phosphatized.

D. Stainless-Steel Sheet: ASTM A 666, Type 304, with No. 4 finish.

E. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise indicated. Do not use metals that are incompatible with joined materials.

1. Use types and sizes to suit unit installation conditions.
2. Use hex-head or Phillips pan-head screws for exposed fasteners unless otherwise indicated.

F. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors made from stainless-steel components, with capability to sustain without failure a load equal to 4 times the loads imposed for concrete, or 6 times the load imposed for masonry, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.

G. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.2 FABRICATION, GENERAL

A. Factory or shop fabricate gravity ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.

B. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

C. Fabricate units with closely fitted joints and exposed connections accurately located and secured.

D. Fabricate supports, anchorages, and accessories required for complete assembly.

E. Perform shop welding by AWS-certified procedures and personnel.

2.3 LOUVERED-PENTHOUSE VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Acme Engineering & Mfg. Corporation.
2. Aerovent.
3. Carnes.
4. Greenheck Fan Corporation.
5. ~~JencoFan.~~
6. ~~5.~~ Loren Cook Company.
7. ~~6.~~ PennBarry.
8. ~~7.~~ Or approved equal.

B. Construction: All-welded assembly with 4-inch-deep louvers, mitered corners, and aluminum or galvanized-steel sheet roof with mineral-fiber insulation and vapor barrier.

C. Frame and Blade Material and Nominal Thickness: Extruded aluminum, of thickness required to comply with structural performance requirements, but not less than 0.080 inch for frames and 0.080 inch for blades with condensate deflectors.
1. AMCA Seal: Mark units with the AMCA Certified Ratings Seal.
2. Exterior Corners: Prefabricated corner units with mitered blades with concealed close-fitting splices and with fully recessed or semirecessed mullions at corners.

D. Frame and Blade Material and Nominal Thickness: Galvanized-steel sheet, of thickness required to comply with structural performance requirements, but not less than 0.052 inch for frames and 0.052 inch for blades with condensate deflectors.
1. AMCA Seal: Mark units with the AMCA Certified Ratings Seal.
2. Exterior Corners: Prefabricated corner units with mitered blades with concealed close-fitting splices and with fully recessed or semirecessed mullions at corners.

E. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch-thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.

1. Configuration: Self-flashing without a cant strip, with built-in raised cant and mounting flange.
2. Overall Height: 9-1/2 inches.

F. Bird Screening: Galvanized-steel, 1/2-inch-square mesh, 0.041-inch wire.

G. Galvanized-Steel Sheet Finish:

1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.
2. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.

3. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's ~~standard~~ Heresite epoxy coating finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil for topcoat and an overall minimum dry film thickness of 2 mils.

   a. Color and Gloss: As selected by Architect from manufacturer's full range.

H. Accessories:

1. Dampers:

   a. See plans and Schedules.

I. Capacities and Characteristics:

1. See plans and Schedules.

2.4 ROOF HOODS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Acme Engineering & Mfg. Corporation.
2. Aerovent.
3. Carnes.
4. Greenheck Fan Corporation.
~~5. JencoFan.~~
~~6.~~5. Loren Cook Company.
~~7.~~6. PennBarry.
~~8.~~7. Or approved equal.

B. Factory or shop fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figures 6-6 and 6-7.

C. Materials: Galvanized-steel sheet, minimum 0.064-inch-thick base and 0.040-inch-thick hood or aluminum sheet, minimum 0.063-inch-thick base and 0.050-inch-thick hood; suitably reinforced.

D. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch-thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.

1. Configuration: Self-flashing without a cant strip, with built-in raised cant and mounting flange.
2. Overall Height: 8 inches.

E. Bird Screening: ~~Galvanized~~Stainless-steel, 1/2-inch-square mesh, 0.041-inch wire.

F. Galvanized-Steel Sheet Finish:

1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a ~~conversion~~ epoxy coating suited to the organic coating to be applied over it.
2. Factory Priming for Field-Painted Finish: ~~Where field painting after installation is indicated, a~~Apply an air-dried Heresite epoxy coating consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil for topcoat and an overall minimum dry film thickness of 2 mils ~~primer~~ immediately after cleaning and pretreating.

G. Capacities and Characteristics:

1. See plans and Schedules.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.

B. Install gravity ventilators with clearances for service and maintenance.

C. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

D. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Section 079200 "Joint Sealants" for sealants applied during installation.

E. Label gravity ventilators according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

F. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

G. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in Section 233113 "Metal Ducts" and Section 233116 "Nonmetal Ducts." Drawings indicate general arrangement of ducts and duct accessories.

3.3 ADJUSTING

A. Adjust damper linkages for proper damper operation.

END OF SECTION 233723

SECTION 237423.16 - PACKAGED, INDIRECT-FIRED, OUTDOOR, HEATING-ONLY MAKEUP-AIR UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes indirect-fired makeup-air units.

1.2 DEFINITIONS

A. DDC: Direct digital control.

1.3 ACTION SUBMITTALS

A. Product Data: For each type and configuration of outdoor, indirect-fired makeup-air unit.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each type and configuration of outdoor, indirect-fired heating and ventilating unit.

1. Signed, sealed, and prepared by or under the supervision of a qualified professional engineer.
2. Include plans, elevations, sections, and mounting attachment details.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Detail fabrication and assembly of gas-fired heating and ventilating units, as well as procedures and diagrams.
5. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
6. 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.
7. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Startup service reports.

B. Sample Warranty: For manufacturer's special warranty.

C. Seismic Qualification Certificates: For outdoor, indirect-fired makeup-air 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.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For indirect-fired makeup-air units 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. Filters: One set(s) for each unit.
2. Fan Belts: One set(s) for each unit.

1.7 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of indirect-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion.

2. Warranty Period for VFD: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. CES Group.
2. Engineered Air.
3. Greenheck Fan Corporation.
4. Trane Inc.

2.2 SYSTEM DESCRIPTION

A. Factory-assembled, prewired, self-contained unit consisting of cabinet, supply fan, controls, filters, and indirect-fired gas burner to be installed exterior to the building.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 UNIT CASINGS

A. General Fabrication Requirements for Casings:

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
2. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
3. Factory Finish for Galvanized-Steel Casings: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on enamel finish, consisting of prime coat and thermosetting topcoat.
4. Casing Coating: Epoxy.
5. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

    a. Seismic Fabrication Requirements: Fabricate mounting base and attachment to air-handling-unit sections, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when air-handling-unit frame is anchored to building structure.

6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Configuration: Horizontal unit with horizontal discharge for roof-mounting or concrete-base installation.

C. Cabinet: Galvanized-steel panels formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs. Duct flanges at inlet and outlet. Pitched

roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.

D. Outer Casing: 0.0478-inch- thick steel with over-corrosion-resistant-treated surface in color to match fan section finish.

E. Inner Casing:

1. Burner Section Inner Casing: 0.0299-inch-thick steel.
2. Double-wall casing with inner wall of perforated steel, for the following sections:

    a. Blower section.
    b. Filter section.
    c. Mixing box.
    d. Inlet plenum.
    e. Discharge plenum.
    f. Access Doors: Hinged with handles for burner and fan motor assemblies on both sides of unit.

3. Internal Insulation: Fibrous-glass duct lining, neoprene coated, comply with ASTM C 1071, Type II, applied on burner and fan sections only.

    a. Thickness: 2 inches.
    b. Insulation Adhesive: Comply with ASTM C 916, Type I.
    c. Density: 2.0 lb/cu. ft..
    d. Mechanical Fasteners: Galvanized steel suitable for adhesive, mechanical, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.

F. Discharge Section:

1. Galvanized-steel assembly with two-position, motorized, parallel-blade dampers with nylon bushings.

    a. Pattern: Double deflection.
    b. Leakage: Low leakage.

2. Trapezoidal cowls with horizontal louvers.
3. Plenum with four sides louvered.
4. Down-discharge plenum insulated with 1-inch, 1.5-lb/cu. ft. fibrous glass.

G. Casing Insulation and Adhesive:

1. Materials: ASTM C 1071, Type II.
2. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of section panels downstream from, and including, the heating-coil section.

    a. Liner Adhesive: Comply with ASTM C 916, Type I.

b. Mechanical Fasteners: Galvanized steel, suitable for adhesive, mechanical, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
c. Liner materials applied in this location shall have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric, depending on service-air velocity.

3. Location and Application: Encased between outside and inside casing.

H. Inspection and Access Panels and Access Doors:

1. Panel and Door Fabrication: Formed and reinforced, single- or double-wall and insulated panels of same materials and thicknesses as casing.
2. Inspection and Access Panels:

a. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
b. Gasket: Neoprene, applied around entire perimeters of panel frames.
c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.

3. Access Doors:

a. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
b. Gasket: Neoprene, applied around entire perimeters of panel frames.
c. Fabricate windows in fan section's doors of double-glazed, wire-reinforced safety glass with an air space between panes and sealed with interior and exterior rubber seals.
d. Size: At least 24 inches wide by full height of unit casing up to a maximum height of 72 inches.

4. Locations and Applications:

a. Fan Section: Doors and inspection and access panels.
b. Access Section: Doors.
c. Coil Section: Inspection and access panels.
d. Damper Section: Inspection and access panels.
e. Filter Section: Inspection and access panels large enough to allow periodic removal and installation of filters.
f. Mixing Section: Doors.

5. Service Light: 100-W vaporproof fixture with switched junction box located inside adjacent to door.

a. Locations: Each section accessed with door.

I. Condensate Drain Pans:

1. Fabricated with two percent slope in at least two planes to collect condensate from condensate-producing heat exchangers and from humidifiers, and to direct water toward drain connection.

    a. Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
    b. Depth: A minimum of 2 inches deep.

2. Formed sections.
3. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
4. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on both ends of pan.

    a. Minimum Connection Size: NPS 1.

5. Pan-Top Surface Coating: Asphaltic waterproofing compound.

2.4 ACCESSORIES

A. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.

B. Coil guards of heresite coated, galvanized-steel wire.

C. Hail guards of galvanized steel, painted to match casing.

D. Air flow measuring station

2.5 OUTDOOR-AIR INTAKE HOOD

A. Type: Manufacturer's standard hood or louver.

B. Materials: Match cabinet.

C. Insect Screen: ¼: #316 SS.

D. Filter: Aluminum, 1 inch cleanable.

E. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.

2.6 ROOF CURBS

A. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

    a. Materials: ASTM C 1071, Type I or Type II.
    b. Thickness: 1-1/2 inches.

2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.

    a. Liner Adhesive: Comply with ASTM C 916, Type I.
    b. 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 cabinet.
    c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
    d. Liner Adhesive: Comply with ASTM C 916, Type I.

C. Curb Height: 14 inches minimum.

D. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match unit, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for wind-load requirements.

2.7 SUPPLY-AIR FAN

A. Fan Type: Centrifugal, rated according to AMCA 210; statically and dynamically balanced, galvanized steel; mounted on solid-steel shaft with heavy-duty, self-aligning, permanently lubricated ball bearings. Bearing rating: L10 of 200,000 hours.

B. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly.

C. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with restrained spring, isolators.

D. Fan-Shaft Lubrication Lines: Extended to a location outside the casing.

E. Variable frequency drive (with no bypass) mounted inside the control enclosure and equipped with fused disconnect.

2.8 AIR FILTERS

A. Comply with NFPA 90A.

B. Cleanable Filters: Cleanable metal mesh.

1. Thickness: 2 inches.
2. Maximum Face Velocity: 450 fpm.

C. Disposable Panel Filters: Factory-fabricated, flat-panel-type, disposable air filters with holding frames, with a MERV 6 according to ASHRAE 52.2.

1. Thickness: 2 inches.
2. Media: Interlaced polyester fibers.
3. Frame: Galvanized steel.
4. Maximum Face Velocity: 450 fpm.

2.9 DAMPERS

A. Outdoor-Air Damper: Extruded aluminum, parrallel-blade dampers with vinyl blade seals and stainless-steel jamb seals, having a maximum leakage of 10 cfm/sq. ft. of damper area, at a differential pressure of 2-inch wg.

B. Damper Operator: Direct coupled, electronic with spring return or fully modulating as required by the control sequence.

2.10 INDIRECT-FIRED GAS BURNER

A. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47, "Gas-Fired Central Furnaces," and with NFPA 54, "National Fuel Gas Code."

1. CSA Approval: Designed and certified by and bearing label of CSA.
2. Burners: Stainless steel.

a. Gas Control Valve: Modulating.
b. Fuel: Natural gas.
c. Minimum Combustion Efficiency: 80 percent.
d. Ignition: Electronically controlled electric spark with flame sensor.

B. Venting: Gravity vented.

C. Venting: Power vented, with integral, motorized centrifugal fan interlocked with gas valve.

D. Combustion-Air Intake: Separate combustion-air intake and vent terminal assembly.

E. Heat Exchanger: Stainless steel.

F. Heat-Exchanger Drain Pan: Stainless steel.

G. Safety Controls:

1. Vent Flow Verification: Differential pressure switch to verify open vent.
2. Control Transformer: 24-V ac.
3. High Limit: Thermal switch or fuse to stop burner.
4. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, electronic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
5. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.

6. Gas Manifold: Safety switches and controls complying with ANSI standards and FM Global.
7. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
8. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
9. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.

2.11 UNIT CONTROL PANEL

A. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.

B. Control Panel: Surface-mounted remote panel, with engraved plastic cover and the following lights and switches:

1. On-off-auto fan switch.
2. Heat-vent-off switch.
3. Supply-fan operation indicating light.
4. Heating operation indicating light.
5. Thermostat.
6. Damper position potentiometer.
7. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
8. Safety-lockout indicating light.
9. Enclosure: NEMA 250, Type 3R.
10. VFD

2.12 CONTROLS

A. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for control equipment and sequence of operation.

B. Control Devices:

1. Remote Thermostat: Adjustable room thermostat with temperature readout.
2. Remote Setback Thermostat: Adjustable room thermostat without temperature readout.
3. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
4. Fire-Protection Thermostats: Fixed or adjustable settings to operate at not less than 75 deg F above normal maximum operating temperature.
5. Timers: Seven-day, programming-switch timer with synchronous-timing motor and seven-day dial; continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover; multiple-switch trippers; minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.
6. Timers: Solid-state, programmable time control with four separate programs; 24-hour battery carryover; individual on-off-auto switches for each program; 365-day calendar

with 20 programmable holidays; choice of fail-safe operation for each program; and system fault alarm.

7. Ionization-Type Smoke Detectors: 24-V dc, nominal; self-restoring; plug-in arrangement; integral visual-indicating light; sensitivity that can be tested and adjusted in place after installation; integral addressable module; remote controllability; responsive to both visible and invisible products of combustion; self-compensating for changes in environmental conditions.

C. Fan Control: Interlock fan to start with exhaust fan(s) to which this heating and ventilating unit is associated for makeup air. Maintain constant air flow regardless the filter loading.

D. Fan Control: Timer starts and stops indirect-fired heating and ventilating unit and exhaust fan(s).

1. Smoke detectors, located in supply air, shall stop fans when the presence of smoke is detected.

E. Outdoor-Air Damper Control, 100 Percent Outdoor-Air Units: Outdoor-air damper shall open when supply fan starts, and close when fan stops.

F. Temperature Control: Operates gas valve to maintain supply-air temperature.

1. Operates gas valve to maintain discharge-air temperature with factory-mounted sensor in blower outlet.
2. Operates gas valve to maintain space temperature with wall-mounting, field-wired sensor with temperature adjustment, and unit-mounted control adjustment and adjustment on remote-control panel.
3. Timer shall select remote setback thermostat to maintain space temperature at 50 deg F.
4. Burner Control: Two or four steps of control using one or two burner sections in series.
5. Burner Control: 20 to 100 percent modulation of the firing rate. 10 to 100 percent with dual burner units.

G. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display status and alarms of heating and ventilating unit.

1. Hardwired Points:

a. Room temperature.
b. Discharge-air temperature.
c. Burner operating.

2. ASHRAE 135.1 (BACnet) communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the heating and ventilating unit from an operator workstation. Control features and monitoring points displayed locally at heating and ventilating unit control panel shall be available through the DDC system for HVAC.

2.13 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
   1. Enclosure: Totally enclosed, fan cooled.
   2. Enclosure Materials: Cast iron.
   3. Efficiency: Premium efficient.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine 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 piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

C. Verify cleanliness of airflow path to include inner-casing surfaces, filters, coils, turning vanes, fan wheels, and other components.

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

3.2 INSTALLATION

A. Equipment Mounting:

   1. Install heating and ventilating units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
   2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
   3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Unit Support: Install heating and ventilating unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

C. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."

D. Install controls and equipment shipped by manufacturer for field installation with indirect-fired heating and ventilating units.

E. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install units on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof

Accessories." Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

F. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

3.3 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Gas Piping: Comply with requirements in Section 231123 "Facility Natural-Gas Piping." Connect gas piping with shutoff valve and union, and with sufficient clearance for burner removal and service. Make final connections of gas piping to unit with corrugated, stainless-steel tubing flexible connectors complying with ANSI LC 1/CSA 6.26 equipment connections.

B. Drain: Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for traps and accessories on piping connections to condensate drain pans under condensing heat exchangers. Where installing piping adjacent to heating and ventilating units, allow space for service and maintenance.

C. Duct Connections: Connect supply ducts to indirect-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Units will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Inspect for visible damage to burner combustion chamber.
2. Inspect casing insulation for integrity, moisture content, and adhesion.
3. Verify that clearances have been provided for servicing.
4. Verify that controls are connected and operable.
5. Verify that filters are installed.
6. Purge gas line.
7. Inspect and adjust vibration isolators and seismic restraints.
8. Verify bearing lubrication.
9. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
10. Set supply air cfm through the VFD and verify it through the air flow measuring station.
11. Set the filter maximum differential pressure.
12. Adjust fan belts to proper alignment and tension.

C. Start unit according to manufacturer's written instructions.

1. Complete startup sheets and attach copy with Contractor's startup report.
2. Inspect and record performance of interlocks and protective devices; verify sequences.
3. Operate unit for run-in period recommended by manufacturer.
4. Perform the following operations for both minimum and maximum firing, and adjust burner for peak efficiency:

    a. Measure gas pressure at manifold.
    b. Measure combustion-air temperature at inlet to combustion chamber.
    c. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

5. Calibrate thermostats.
6. Adjust and inspect high-temperature limits.
7. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
8. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
9. Measure and record airflow. Plot fan volumes on fan curve.
10. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:

    a. High-limit heat.
    b. Alarms.

11. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
12. Verify drain-pan performance.
13. Verify outdoor-air damper operation.

3.6 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months from 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.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain heating and ventilating units.

END OF SECTION 237423.16

SECTION 238127 - VARIABLE REFRIGERANT FLOW SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for exposed or concealed mounting and may be connected to ducts.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. LEED Submittals:

1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

D. Samples for Initial Selection: For units with factory-applied color finishes.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Sample of special warranty.

C. Required Format for Submittals:
1. Shop Drawings and Product Data shall meet the requirements.
2. Shop drawings shall be 11 inch by 17 inch, landscape, bound on the left edge. They shall be produced with AUTOCad or Microsoft Visio. Organize the packages by building and floors.
3. All text based documents and product data sheets shall be 8-1/2 inch by 11 inch format bound on the left edge. To the maximum extent possible Adobe Acrobat shall be used to produce the documents in an X.pdf format.

4. Software files shall be submitted on fully labeled CDs that shall include a table of contents file in pdf format that provides a description of all of the files on the CD and or USB Drive.
5. Requirement for Shop Drawings:
    a. System Architecture Design Diagram:
        1) This is a riser diagram that shall show the IP layers and all of the field bus layers.
        2) It shall show each router, repeater, controller and protocol translator that is connected to either the IP layer or any of the field busses.
        3) This diagram shall include the existing control system that is to be integrated into the common enterprise level system.
        4) Each component that is shown shall have a name that is representative of how it will be identified in the completed database and the manufacturer's name and model number. Example: Device A10: FCU1 Controller, XXX, IHM Model 1401Z0
        5) The physical relationship of one component to another component shall reflect the proposed installation with detailed wiring diagrams.
        6) This diagram shall not include power supplies, sensors or end devices.
    b. Layout Design Drawing for each control panel:
        1) The layout drawing shall be with all devices shown in their proposed positions.
        2) All control devices shall be identified by name.
        3) All terminal strips and wire channels shall be shown and labeled
        4) All control transformers shall be shown and labeled
        5) All 120 VAC receptacles shall be shown and labeled
        6) All IP connection points shall be shown and labeled
    c. Wiring Design Diagram for each control panel:
        1) The control voltage wiring diagram shall clearly designate devices powered by each control transformer. If the control devices use half-wave power, the diagram shall clearly show the consistent grounding of the appropriate power connection. All wire identification numbers shall be annotated on the diagram.
        2) The VRF Bus wiring diagram shall clearly show the use of the daisy chain wiring concept, the order in which the devices are connected to the FCU and EF and the location of end of segment termination devices. All wire identification numbers shall be annotated on the diagram.
        3) If shielded communication wiring is used, the grounding of the shield shall be shown.
        4) The terminal strip wiring diagram shall identify all connections on both sides of the terminal strip. Wiring label numbers for all wiring leaving the control panel shall be annotated on the diagram.
    d. Wiring Design Diagram for individual components (controllers, protocol translators, etc.):
        1) The wiring diagram for each component shall identify all I/O, power and communication wiring, and the locations on the terminal blocks to which the wires are landed. Example: Fan Status sensor is wired from terminals 5/6 on the controller to terminals 17 and 18 on the terminal strip.
    e. Installation Design Detail for each I/O device:
        1) Include a drawing of the wiring details for each sensor and/or end device.

2) For devices with multiple quantities a standard detail may be submitted.
a) Note: The standard detail drawing must be accompanied by a list of the locations where the devices will be installed.

6. Requirements For Product Data:
a. Direct Digital Control System Hardware Technical Data.
1) A complete bill of materials of equipment to be used indicating quantity, manufacturer and model number.
2) Manufacturer's description and technical data for each unique device to include performance curves, product specification sheets and installation instructions. When a manufacturer's data sheet refers to a series of devices rather than a specific model, the data specifically applicable to the project shall be highlighted or clearly indicated by other means.
3) This requirement applies to:
a) Controllers
b) Transducers / Transmitters
c) Sensors
d) Actuators
e) Valves
f) Relays and Switches
g) Control Panels
h) Power Supplies
i) Batteries
b. An Instrumentation List for each system:
1) The list shall be in a table format.
2) Include name, type of device, manufacturer, model number and product data sheet number.

D. Turnover Documents after Completion and Commissioning:
1. The following is a list of post construction turnover documentation that shall be updated to reflect any changes during construction and re-submitted as "As-Built."
a. System architecture drawing.
b. Layout drawing for each control panel.
c. Wiring diagram for each control panel.
d. Wiring diagram for individual components.
e. System flow diagram for each controlled system.
f. Instrumentation list for each controlled system.
g. Sequence of controls.
2. Operation and Maintenance Manuals:
a. Operations and Maintenance Manuals shall consist of two parts. The information shall be in three ring binders with tabs and a table of contents. Diagrams shall be on 11" by 17" foldouts. If color has been used to differentiate information, the printed copies shall be in color.
b. Part I: Information common to the entire system. This shall include but not be limited to the following.
1) Product manuals for the key software tasks.
a) Operating the system.
b) Administrating the system.
2) System Architecture Diagram.
3) List of recommended maintenance tasks associated with the system servers, operator workstations, data servers, web servers and web clients.
a) Define the task.

b) Recommend a frequency for the task.
c) Reference the product manual that includes instructions on executing the task.

4) Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
5) Licenses, guarantees, and warranty documents for equipment and systems.
6) Submit one copy for each building, plus two extra copies.

c. Part II: Information common to the systems in a single building.
1) System architecture diagram for components within the building annotated with specific location information.
2) As-built wiring design diagram for each control panel.
3) As-built wiring design diagram for all components.
4) Installation design details for each I/O device.
5) As-built system flow diagram for each system.
6) Sequence of control for each system.
7) Product data sheet for each component.
8) Installation data sheet for each component.
9) Description of system commissioning protocol and procedures in binder with two extra copies.
10) Initial system change control log in binder.
11) Submit two copies for each building and two extra copies for file.

3. Software:
a. Submit a LICENSED COPY of all software.
b. All software revisions shall be as installed at the time of the system acceptance. All submittals will include all revisions

4. Firmware Files:
a. Submit a copy of all firmware files that were downloaded to or pre-installed on any devices installed as part of this project.
b. This does not apply to firmware that is permanently burned on a chip at the factory and can only be replaced by replacing the chip.
c. Submit a copy of all secondary graphic files on DVD such as bitmaps, jpegs, etc. that were used in the creation of the graphic pages.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set for each air-handling unit.

1.6 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 - " Procedures," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.8 WARRANTY

A. The units shall have a manufacturer’s parts only warranty for a period of two (2) year from date of installation. The compressors shall have a parts only warranty of seven (7) years from date of installation. A completed commissioning report shall be submitted to the manufacturer by a certified installer. During the stated period, should any part fail due to defects in material and workmanship, it shall be repaired or replaced at the discretion of the manufacturer according to their terms and conditions. All warranty service work shall be performed by the manufacturers factory trained service professional.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. LG Electronics USA: Air Conditioning Division
2. Mitsubishi Electric & Electronics USA, Inc.; HVAC Advanced Products Division.
3. Daikin: Air Conditioning and Refrigeration Business
4. Trane; a business of American Standard companies.
5. Or approved equal.

2.2 INDOOR UNITS

A. General
1. Unit shall be factory assembled, wired, piped and run tested.
2. Unit shall be horizontal ducted or wall mount ductless as indicated on the plans
3. Unit shall be designed to be installed for indoor application.
4. The supply air shall be flanged for field installed ductwork that shall not exceed the external static pressure limitation of the unit.
5. Unit shall be capable to be installed with heat pump or heat recovery or cooling VRF system.

B. Casing/Panel
1. Unit case shall be manufactured using galvanized steel plate.
2. The cold surfaces of the unit shall be covered internally with a coated polystyrene insulating material.
3. The cold surfaces of the unit shall be covered externally with sheet insulation made of Ethylene Propylene Diene Monomer (M-Class) (EPDM)
4. The external insulation shall be plenum rated and conform to ASTM Standard D-1418.
5. Unit shall be provided with hanger brackets designed to support the unit weight on four corners.
6. Hanger brackets shall have pre-punched holes designed to accept field supplied, all thread rod hangers.
7. Wall mount ductless units shall manufactured using Acrylonitrile Butadiene Styrene (ABS) polymeric resin and has a morning fog finish.

C. Cabinet Assembly
1. Unit shall be equipped with factory installed temperature thermistors for
   a. Return air
   b. Refrigerant entering coil.
   c. Refrigerant leaving coil.
2. Unit shall have a factory assembled, piped and wired electronic expansion valve (EEV) for refrigerant control.
3. Unit shall have a built-in control panel to communicate with other indoor units and to the outdoor unit.
4. Unit shall have the following functions as standard
   a. Self-diagnostic function
   b. Auto restart function
   c. Auto changeover function (Heat Recovery system only)
   d. Auto operation function
   e. Child lock function
   f. Forced operation
   g. Dual thermistor control
   h. Sleep mode
   i. External static pressure (ESP) control

D. Fan Assembly
1. The unit shall have two direct driven Sirocco fans.
2. The fan shall be made of high strength ABS GP-2200 polymeric resin.
3. The fans shall be mounted on a common shaft.
4. The fan motor shall be Brushless Digitally controlled (BLDC) with permanently lubricated and sealed ball bearings.

5. The fan/motor assembly shall be mounted on vibration attenuating rubber grommets.
6. The fan speed shall be controlled using microprocessor based direct digitally controlled algorithm.
7. In cooling mode, the indoor fan shall have the following settings: Low, Med, High and Auto.
8. In heating mode, the indoor fan shall have the following settings: Low, Med, High and Auto.
9. The Auto fan setting shall adjust the fan speed to most effectively achieve the set-point.
10. Each of the settings can be field adjusted from the factory setting (RPM/ESP).
11. Unit shall be designed for high speed air volume against an external static pressure of up to 1.0" water gauge.

E. Filter Assembly
1. Horizontal ducted units shall be provided with a field mounted return filter box. Filter shall be high-efficiency 2" MERV 13 not to exceed external static pressure limitation of the high static ducted indoor unit.
2. Ductless wall mount units shall have a factory supplied removable, washable filter.

F. Coil Assembly
1. Unit shall have a factory built coil comprised of aluminum fins mechanically bonded on copper tubing.
2. Unit shall have minimum of 2 rows of coils.
3. Unit shall have a factory supplied condensate drain pan below the coil.
4. Horizontal unit shall be installed and wired condensate drain pump capable of providing minimum 27.5 inch lift from bottom surface of the unit.
5. Vertical unit shall be designed for gravity drain.
6. Unit drain pan shall be provided with a secondary drain port/plug allowing pan to be drained for service.
7. The drain pump shall have a safety switch to shut off the unit if condensate rises too high in the drain pan.
8. Unit shall have provision of 45° flare refrigerant pipe connections
9. The coil shall be factory pressure tested at a minimum of 551 psig.
10. All refrigerant piping from outdoor unit or Heat Recovery (HR) unit to indoor unit shall be field insulated.

G. Microprocessor Control
1. The unit shall have a factory installed microprocessor controller capable of performing functions necessary to operate the system.
2. The unit shall be able to communicate with other indoor units and the outdoor unit using a field supplied minimum of 18 AWG, 2 core, stranded and shielded communication cable.
3. The unit controls shall operate the indoor unit using one of the five operating modes:
   a. Auto changeover (Heat Recovery System only)
   b. Heating
   c. Cooling
   d. Dry
   e. Fan only

H. Electrical
1. The unit electrical power shall be 208-230/1/60 (V/Ph/Hz)

2. The unit shall be capable of operating within voltage limits of +/- 10% of the rated voltage.

I. Controls
1. Unit shall use controls provided by the manufacturer to perform all functions necessary to operate the system effectively and efficiently and communicate with the outdoor unit over an RS485 daisy chain.

2.3 OUTDOOR UNITS

A. General:
1. The air-conditioning system shall use R410A refrigerant.
2. Each system shall consist of one, two or three air source outdoor unit frame.
3. Dual and triple frame configurations shall be field piped together using manufacturer's designed and supplied Y-branch kit in conjunction with field provided interconnecting pipe to form a common refrigerant circuit.
4. Refrigerant circuit configuration for Heat Recovery System
   a. The refrigerant circuit shall be constructed using field provided copper piped together with manufacturer supplied Heat Recovery unit(s) ,Y- branches or Header fittings, connected to (ducted, non-ducted or combination thereof) single/multiple indoor units to effectively and efficiently control the simultaneous heating and cooling operation of the VRF system.
   b. Each refrigerant pipe, y-branch, header kit, elbows and isolation ball valves shall be individually insulated with no air gaps. All joints shall be glued and sealed.
5. Factory installed microprocessor controls in the outdoor unit(s), HR unit(s), and indoor unit(s) shall perform functions to efficiently operate the VRF system and communicate in a daisy chain configuration between each other. Communications and cabling shall conform to RS485 standard.
6. The system shall be designed to accept connection up to 58 indoor units depending on the outdoor unit model selected.
7. The outdoor unit shall have a fusible plug.
8. The fusible plug shall have a threaded connector.
9. The unit shall be shipped from the factory fully assembled including internal refrigerant piping, compressor, contacts, relay(s), power and communications wiring necessary.
10. Each refrigeration circuit shall have the following components:
    a. Refrigerant strainer(s)
    b. Check valve(s)
    c. Oil separator
    d. Accumulator
    e. 4-way reversing valve
    f. Vapor injection valve
    g. Variable path valve
    h. Oil balancing valve for Hi-POR (Available for 12 & 14 ton only)
    i. Oil Level sensor
    j. Electronic expansion valve(s)
    k. Sub-cooler
    l. High and low side Schrader valve service ports with caps.
    m. Service Valves

B. Unit Cabinet:

1. Outdoor unit cabinet shall be made of 20 gauge galvanized steel with an enamel finish.
2. Outdoor unit cabinet finish shall be tested in accordance with ASTM B-117 salt spray test procedure for a minimum of 1000 hours.
3. The front panels of the outdoor units shall be removable type for access to internal components.
4. A smaller service access panel, not larger than 6.25"x 6.67" and secured by a maximum of (2) screws shall be provided to access the following:
   a. Service tool connection
   b. DIP switches
   c. Auto addressing
   d. Error codes
5. The cabinet shall have piping knockouts to allow refrigerant piping to be connected at the front or through the bottom of the unit.

C. Fan:
1. Each 6 ton cabinet shall be equipped with one direct drive variable speed propeller fan with Brushless Digitally Controlled (BLDC) motor with a vertical air discharge.
2. Each 8 to 14 ton cabinet shall be equipped with two direct drive variable speed propeller fan(s) with BLDC motor(s) with a vertical air discharge.
3. The fan(s) blades shall be made of Acrylonitrile Butadiene Styrene (ABS) material.
4. The fan(s) motor shall be equipped with permanently lubricated bearings.
5. The fan motor shall be variable speed with a maximum operating speed of 1050 RPM.
6. The fan shall have a raised guard to help prevent contact with moving parts.
7. The cabinet shall have option to change the discharge air direction from vertical to horizontal using optional factory provided air guides.
8. The cabinet shall have DIP switch setting to raise external static pressure up to 0.32 in-wg.

D. Condenser Coil:
1. The outdoor unit shall have a factory built coil comprised of aluminum fins mechanically bonded on copper tubing.
2. The copper tubes shall have inner groves.
3. The aluminum fins shall have factory applied corrosion resistant GoldFin™ material.
4. Hydrophilic Coil coating shall be tested in accordance with ASTM B-117 salt spray test procedure for a minimum of 1000 hours
5. The outdoor unit coil shall be tested to a pressure of 551 psig.
6. The coil for each cabinet shall have 14 Fins per Inch (FPI).
7. All the outdoor units shall have a 3 rows heat exchanger.
8. The cabinet shall have a coil guard.

E. Compressor:
1. Each 6, 8, 10 ton cabinet shall be equipped with one hermetically sealed, inverter driven, High Side Shell (HSS) scroll compressor.
2. The 12 and 14 ton cabinet shall be equipped with two hermetically sealed, inverter driven, HSS controlled scroll compressors.
3. Each inverter driven, HSS scroll compressor shall be capable of operating in a frequency range from 15 Hz to 150 Hz with control in 0.5 Hz increments.
4. The compressor(s) shall be equipped with a 60 Watt crankcase heater.
5. The compressor shall use a factory charge of Polyvinyl Ether (PVE) oil.
6. The compressor bearing(s) shall have Teflon™ coating.
7. The compressor(s) shall be protected with:

a. High Pressure switch
b. Over-current /under current protection
c. Phase failure
d. Phase reversal

8. Standard, non-inverter driven compressors shall not be permitted

F. Oil Management
1. The system shall have Hi-POR (High Pressure Oil Return) to ensure a consistent film of oil on all moving compressor parts at low speed. Oil is returned to compressor through a separate oil injection pipe.
a) Oil return system shall maintain high side pressure return to the compressor
2. The system shall be provided with a centrifugal oil separator designed to extract oil from the oil/refrigerant gas stream leaving the compressor and return the extracted oil to the compressor oil sump.
3. The system shall have an oil level sensor in the compressor to provide direct oil level sensing.
4. The system shall only initiate an oil return cycle if the oil level is too low.
5. Timed oil return operations or non-oil level sensing systems shall not be permitted.

G. Refrigerant Management
1. System shall have advanced refrigerant control functions that optimize operating efficiency at all ambient operating conditions. Advanced refrigerant control functions shall include:
2. Accumulator shall be equipped with controls that vary the amount of refrigerant charge being circulated based on operating mode.
3. Outdoor unit coil shall be equipped with controls that maximizes heat transfer. Controls shall vary the coil circuiting between parallel and series configurations and be able to change flow direction in response to multiple refrigerant monitoring parameters and operating conditions.
4. Compressors shall be equipped with an intermediary port that introduces additional refrigerant to the compression chamber based on multiple refrigerant system monitoring parameters. This feature increases heating capacity at low ambient conditions.
5. System shall have advanced refrigerant control functions that optimize operating efficiency at all ambient operating conditions. Advanced refrigerant control functions shall include:

H. Sound Levels
1. Each cabinet shall be rated with a sound level not to exceed 59.5 dB(A) when tested in an anechoic chamber under ISO3745 standard.

I. Sensors
1. Each single cabinet shall have
2. Suction temperature sensor
3. Discharge temperature sensor
4. High Pressure sensor
5. Low Pressure sensor
6. Outdoor temperature sensor
7. Outdoor unit heat exchanger temperature sensor

2.4 HEAT RECOVERY UNIT (HRU) FOR HEAT RECOVERY SYSTEM

A. General
1. HR unit shall be designed and manufactured by the same manufacturer of VRF indoor unit(s) and outdoor unit(s).
2. HR unit casing shall be made with galvanized steel.
3. HR unit shall require 208-230V/1-phase/60Hz power supply.
4. HR Unit shall be an intermediate refrigerant control device between the air source outdoor unit and the indoor units to control the systems simultaneous cooling and heating operation.
5. HR unit shall be engineered to work with a three pipe VRF system comprising of
   a. High Pressure Vapor Pipe
   b. Low Pressure Vapor Pipe
   c. Liquid Pipe
6. HR unit shall be designed to be piped in series or parallel.
7. HR unit shall have 2, 3 or 4 ports.
8. Each port shall be capable of operating in cooling or heating independently regardless of the operating mode of any other port on the HR unit or in the system.
9. Each port shall be capable of connecting from 1 to 8 indoor units to a maximum nominal capacity of 54MBh.
10. Maximum nominal capacity per HR unit shall not exceed 192MBh.
11. Indoor units greater than 54MBh nominal capacity shall be twinned using a reverse Y-branch.
12. HR unit shall be internally piped, wired, assembled and run tested at the factory.
13. HR unit shall be designed for installation in a conditioned environment.
14. HR unit shall have a liquid bypass valve.
15. HR unit shall have (2) two-position solenoid valves per port.
16. HR unit shall have a balancing valve to control the pressure between the high pressure and low pressure pipe during mode switching.
17. HR unit shall have an electronic expansion valve for subcooling.
18. HR unit shall not require a condensate drain.
19. HR unit shall be internally insulated.
20. All field refrigerant lines between outdoor unit and HR unit and from HR unit to indoor unit shall be field insulated.
21. The HR unit shall not exceed a net weight of 49 lbs.
22. The system shall be designed to accommodate 16 HR units connected to Heat Recovery units piped in single series string.
23. A single series pipe string of 1 to 16 HR units shall be capable of serving indoor units with a total nominal capacity of 192 MBH per HR unit.

B. Piping Capabilities
1. The elevation difference between indoor units on heat pump systems shall be 131 feet.
2. The elevation differences for heat recovery systems shall be:
   a. Heat recovery unit (HRU) to connected indoor unit shall be 49 feet
   b. HRU to HRU shall be 49 feet
   c. Indoor unit to indoor unit connected to same HRU shall be 49 feet
   d. Indoor unit to indoor unit connected to separate parallel HRU’s shall be 131 feet.
3. The acceptable elevation difference between two series connected HR units shall be 16 feet.

C. Controls

1. HR unit(s) shall have factory installed unit mounted control boards and integral microprocessor to communicate with other devices in the VRF system.
2. HR unit shall communicate with the air source unit via the air source/indoor unit 2-conductor shielded communications cable terminated using a daisy chain configuration.
3. The VRF manufacturer shall provide published documentation that specifically allows the installation of field provided isolation valves on all pipes connected to the Heat Recovery unit to allow the servicing of HR units refrigerant circuit or the replacement of HR unit without evacuating the balance of the piping system.

2.5 CENTRAL CONTROLLER – ACP IV BACnet Gateway (One per Building)

A. General
1. Shall have a time clock with 12/24 hour format and calendar.
2. Shall have 10/100 BASE-T Ethernet BACnet connection.
3. Shall be powered by 24 VAC (field provided)
4. Shall be capable of controlling a minimum of 128 devices without need for expansion device.
5. Shall be compatible with another of the same controller for master/slave control of all units on the communications bus.
6. Shall have micro USB port for software updates, configuration backups, saving logged data, and uploading graphics.
7. Shall have minimum two digital inputs and two digital outputs for remote system shutdown and device monitoring/control and interlocking.
8. Shall have operation and error history log.

B. Basic Functions
1. Shall control AC unit or ventilator On/Off.
2. Shall control Mode.
3. Auto/Cool/Dry/Heat/Fan Only for AC unit.
4. Recovery/Bypass/Auto for ventilator unit.
5. Shall control AC unit discharge vanes – Auto/Swing/Fixed.
6. Shall have remote controller lock function – All/Setpoint/Mode/Fan Speed.
7. Error code display during unit or system malfunction.

C. Advanced Functions
1. 200 programmable schedule events with control of setpoint, On/Off, Mode, Fan Speed, Controller Lock, and Louver Swing.
2. Shall have two setpoint auto-changeover function.
3. Shall have two setpoint setback function.
4. Shall have Temperature Setpoint Range Limit.
5. Shall have AC unit run time limit (unoccupied override).
6. Shall have software device interlocking for linking control of multiple devices.
7. Shall have manual control and scheduling of Digital Output Kit.
8. Shall have AC unit Peak Control function to limit energy usage.
9. Shall have Visual Floor plan Navigation.
10. Shall have unit and system error e-mail notification.
11. Shall be capable of displaying and e-mailing energy usage information from Power Distribution Indicator (PDI) unit (optional).

※ Aircon

	Name	Object Name (XXX : Unit Address Number)	Object Type	Unit					
				Inactive	Active				
				TEXT-0	TEXT-1	TEXT-2	TEXT-3	TEXT-4	TEXT-5
1	On/Off (Setting)	StartStopCommand_XXX	BO	Stop(0)	Start(1)				
2	On/Off (Status)	StartStopStatus_XXX	BI	Stop(0)	Start(1)				
3	Lock (Setting)	LockCommand_XXX	BO	Permit(0)	Prohibit(1)				
4	Lock (Status)	LockStatus_XXX	BI	Permit(0)	Prohibit(1)				
5	Filter Sign	FilterSign_XXX	BI	Off(0)	On(1)				
6	Filter Sign reset	FilterSignReset_XXX	BV	-	Reset(1)				
7	Operation Mode (Setting)	AirConModeCommand_XXX	MO		Cool(1)	Dry(2)	Fan(3)	Auto(4)	Heat(5)
8	Operation Mode (Status)	AirConModeStatus_XXX	MI		Cool(1)	Dry(2)	Fan(3)	Auto(4)	Heat(5)
9	Swing (Setting)	SwingCommand_XXX	BO	Stop(0)	Run(1)				
10	Swing (Status)	SwingStatus_XXX	BI	Stop(0)	Run(1)				
11	Fan Speed (Setting)	FanSpeedCommand_XXX	MO		Low(1)	Middle(2)	High(3)	Auto(4)	
12	Fan Speed (Status)	FanSpeedStatus_XXX	MI		Low(1)	Middle(2)	High(3)	Auto(4)	
13	Set Room Temperature	SetRoomTemp_XXX	AV	℃ Cool(18~30), Heat(16~30)					
14	Room Temperature	RoomTemp_XXX	AI	℃					
15	Alarm	Alarm_XXX	BI	Normal(0)	Abnormal(1)				
16	Error Code	MalfunctionCode_XXX	AI	Refer to the LG Errror code list					
17	-	-	-						
18	-	-	-						
19	Set Temperature (Status)	SetTempStatus_XXX	AI	℃					
20	Accumulator Power Distribution (Status)	Accumulated power(100 Watt)_XXX	AI	Wattage values (Unit : 100Watt)					
21	-	-	-						
22	-	-	-						
23	-	-	-						
24	-	-	-						
25	-	-	-						
26	-	-	-						
27	Set Upper Temperature (Setting)	TempRangeUpperLimitCommand_XXX	AV	℃					
28	Set Lower Temperature (Setting)	TempRangeLowerLimitCommand_XXX	AV	℃					
29	Set Upper Tempaerature (Status)	TempRangeUpperLimitStatus_XXX	AI	℃					
30	Set Lower Temperature (Status)	TempRangeLowerLimitStatus_XXX	AI	℃					
31	Mode Lock (Setting)	ModeLockCommand_XXX	BO	Permit(0)	Prohibit(1)				
32	Mode Lock (Status)	ModeLockStatus_XXX	BI	Permit(0)	Prohibit(1)				
31	Fan Lock (Setting)	FanLockCommand_XXX	BO	Permit(0)	Prohibit(1)				
32	Fan Lock (Status)	FanLockStatus_XXX	BI	Permit(0)	Prohibit(1)				

※ I/O Module for Exhaust Fans

	Name	Object Name (XXX : Unit Address Number)	Object Type	Unit					
				Inactive	Active				
				TEXT-0	TEXT-1	TEXT-2	TEXT-3	TEXT-4	TEXT-5
1	On/Off (Setting)	StartStopCommand_XXX	BO	Stop(0)	Start(1)				
2	On/Off (Status)	StartStopStatus_XXX	BI	Stop(0)	Start(1)				

※ Out Door Unit

	Name	Object Name (XXX : Unit Address Number)	Object Type	Unit					
				Inactive	Active				
				TEXT-0	TEXT-1	TEXT-2	TEXT-3	TEXT-4	TEXT-5
1	Compressor Operation Status	CompOperStatus_XXX	BI	Stop(0)	Run(1)				
2	Refrigent Type	RefrigentType_XXX	MI		R407C(1)	R22(2)	R410A(3)		
3	Inverter Fan 1 frequency	InverterFanFreq_XXX	AI	-					
4	High Pressure	HighPressure_XXX	AI	-					
5	Low Pressure	LowPressure_XXX	AI	-					
6	Suction Temperature	SunctionTemp_XXX	AI	℃					
7	Liquid Pipe Temperature	LiquidPipeTemp_XXX	AI	℃					
8	Heat Exchanger Temperature	HexTemp_XXX	AI	℃					
9	Outdoor EEV	OutdoorEEV_XXX	AI	-					
10	Subcool EEV	SubCoolEEV_XXX	AI	-					
11	Hot Gas Valve	HotgasValue_XXX	BI	Stop(0)	Run(1)				
12	Inverter Discharge Temperature	InverterDischargeTemp_XXX	AI	℃					
13	Outdoor Temperature	OutdoorTemp_XXX	AI	℃					
14	Operation Mode	OperationMode_XXX	MI		R407C(1)	R22(2)	R410A(3)		

D.

2.6 HVAC EQUIPMENT – BACnet SERVER

A. Equipment provided under this section shall be provided with a BACnet Server (ASHRAE Standard 135) interface fully configured and ready for BACnet MS/TP communications by the equipment provider. Equipment shall be configured and enabled for BACnet discovery and integration to the associated BACnet Router, or Building Controller (B-BC), and subsequently to the BACnet Advanced Operator Workstation (B-AWS) front-end system.

B. The equipment shall be fully programmed and configured utilizing only open, BACnet objects including the following object types: analog input, analog output, analog value, binary input, binary output, binary value, and alarm objects. BACnet proprietary objects, or manufacturer specific, BACnet container points and multi-state points having more than 5 states defined shall not be utilized.

C. BACnet Server systems and devices shall be BTL tested, listed, and certified with a copy of the BTL certificate included in the submittal package.

D. The equipment submittal package shall be provided to and the Control System Integrator for review and approval. The submittal documentation shall include a list of the equipment being provided and the Instance ID and MAC address for each piece of equipment. This is required for all BACnet MS/TP communicating devices and equipment provided under this section.

E. Equipment submittals shall also include the BACnet Protocol Implementation Conformance Statement (PICs) and a completed BACnet point table that lists each point including:
   1. Point name that conforms to the County of Monterey point naming convention.
   2. Unique description of each point.
   3. Indication of the functionality supported and enabled for each BACnet object (i.e. Read, Writeable, Trend, Schedule, Notifications) to facilitate integration and interoperability
   4. Default Alarm High and Low values with indication of adjustable/writeable.
   5. All BACnet objects (points) referenced in the design drawings and sequences of operation for the subject equipment shall be defined and configured by the equipment supplier for BACnet MS/TP discovery and routing to the BACnet client for display and command/control integration as defined in the below tables for the equipment including the minimum points and functionality indicated. Any deviation regarding support of the required points list and functionality shall be described in the equipment proposal and submittals and approved in advance by the County of Monterey and the Control Systems Integrator.

F. The equipment/subsystem shall be provided with ALL software, licensing, hardware, and inter-connecting cables, accessories, tools and modules required to make programming and configuration changes to the delivered devices and equipment.

G. The equipment supplier shall coordinate with the Section 230900 instrumentation and control contractor and be present on site to provide support and any troubleshooting necessary to properly enable and configure the equipment for standard BACnet discovery by the BACnet client B-AWS system to ensure successful integration and start-up.

H. Note that equipment shall not be commissioned and started-up until after the BACnet point data has been fully integrated into the BACnet client B-AWS front-end and verified by the County of Monterey and the Section 230900 instrumentation and control.

2.7 CAPACITIES AND CHARACTERISTICS

A. See Drawings and Schedules.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install roof-mounted, compressor-condenser components on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

D. Equipment Mounting:

1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 WIRING

A. All control and interlock wiring shall comply with national and local electrical codes and Division 25 of this specification. Where the requirements of this section differ from those in Division 27, the requirements of this section shall take precedence.

B. All NEC Class 1 (line voltage) wiring shall be UL Listed in approved raceway according to NEC and Division 26 requirements.

C. Low voltage wiring shall meet NEC Class 2 requirements. Sub-fuse low voltage power circuits as required to meet Class 2 current limits.

D. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL Listed for the intended application.

E. All wiring in mechanical, electrical, or service rooms, or where subject to mechanical damage, shall be installed in raceway at levels below 11 feet.

F. Class 2 Wiring shall not be installed in raceway containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).

G. Wiring shall not be installed in a raceway containing tubing.

H. Where Class 2 wiring is exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 8 foot intervals.

I. Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.

J. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire to wire connections shall be at a terminal block.

K. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

L. Maximum allowable voltage for control wiring shall be 125 Volts. If only higher voltages are available, the contractor shall provide step-down transformers.

M. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

N. Install plenum wiring in sleeves where it passes through walls and floors. Maintain the fire rating at all penetrations.

O. The size of raceway and size and type of wire shall be the responsibility of the contractor, in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.

P. Include one pull string in each raceway that is 1 inch in diameter or larger.

Q. Use coded conductors throughout with conductors of different colors.

R. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

S. Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway, to maintain a minimum clearance of 9 inches from high-temperature equipment such as steam pipes, electrical transformers or flues.

T. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap, plumber tape or tie rods. Raceways may not be run on or attached to air distribution ductwork.

U. Adhere to specification requirements where raceway crosses building expansion joints.

V. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.

W. The contractor shall terminate all control and/or interlock wiring and shall maintain updated as-built wiring diagrams with terminations identified at the job site.

X. Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 2.5 feet in length and shall be supported at each end. Flexible metal raceway less than ½ inch electrical trade size shall not be used. In areas exposed to moisture liquid-tight, flexible metal raceways shall be used.

Y. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with coupling according to code. Terminations must be made with fittings at boxes and ends not terminating in boxes shall have protective bushings installed.

3.3 COMMUNICATION WIRING

A. The contractor shall adhere to the items listed in the previous section on WIRING.

B. The contractor shall install all cabling in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.

C. The contractor shall not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.

D. When a cable enters or exits a building, the contractor shall install a lighting arrestor between the lines and ground. The lighting arrestor shall be installed according to the manufacturer's instructions.

E. The contractor shall install all runs of communication wiring with un-spliced lengths when that length is commercially available.

F. The Contractor shall provide a permanent tagged label on all communication wiring to indicate origination and destination data.

G. The Contractor shall ground coaxial cable in accordance with NEC regulations on "Communications Circuits, Cable, and Protector Grounding."

H. When shielded wiring is use, the Contractor shall ground the shield only once for each continuous segment of cable. The grounding location shall be at the end of the segment that is most readily accessible.

3.4 SENSORS

A. The contractor shall install sensors in accordance with the manufacturer's recommendations.

B. The contractor shall mount sensors rigidly and adequately for the environment within which the sensor operates.

C. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.

D. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

3.5

3.6 CONNECTIONS

A. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

3.7 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. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.8 VRF CONTROL SYSTEM CHECKOUT, TESTING AND TRAINING

A. The contractor shall furnish all labor and test apparatus required to execute the start up testing and owners commissioning plan. Key tasks to be executed and documented in the start-up testing and commissioning verification report include:
1. Verification of all primary and secondary voltages.
2. Verification that power wiring for all devices conforms to manufacturer's instructions.
3. Verification that all labeling is in place.
4. Verification and Inspection of wiring for loose strands and tight connections.
5. Verification and Inspection of all control panel electrical grounding
6. Verification of field bus topology, grounding of shields (if used) and installation of termination devices.
7. Verification that each I/O device is landed per the submittals and functions per the sequence of control.
    a. Analog sensors shall be properly scaled and a value reported to the OWS.
    b. Binary sensors shall have the specified normal position and the state is reported to the OWS.
    c. Analog outputs have the specified normal position and move full stroke when so commanded.

d. Binary outputs have the specified normal state and respond to energize / de-energize commands.

8. Analog sensors have been calibrated with high quality instrumentation suitable for the sensor being calibrated.
   a. The instruments shall display a current (12 month) NIST traceable calibration sticker. Associated instrument calibration certificates shall be made available within 24 hours of a request.
   b. The measured value, reported value, and the calculated offset that was entered into the database shall be recorded.
   c. The calibration criteria shall be:
      1) Space Temperature: +/- 0.4 degrees F
      2) Air Temperature: +/- 0.5 degrees F
      3) Differential Pressure: +/- 3 %
      4) Gauge Pressure: +/- 5%
      5) CO_2: +/- 2 %

3.9 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.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 238126

DIVISION 26 – ELECTRICAL

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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section covers and applies to all work specified in Division 26 (and 27 & 28).

B. Work Included: Materials, equipment, fabrication, installation and tests for fully operational and safe systems, including all necessary materials, appurtenances and features whether specified or shown on drawings or not, in conformity with applicable codes and authorities having jurisdiction for the following:

1. Electrical work specified in all sections within Division 26 (and 27 & 28) of these specifications, including, but not limited to:

    a. Short circuit analysis.
    b. Primary underground service ducts from the point of connection to the Serving Agency to the transformer vault, building main switchboard.
    c. Equipment for serving agency facilities shall be furnished and installed in accordance with the requirements of the Serving Utility. Transformers, primary cable, and utilization equipment will be furnished and installed by the Serving Agency.
    d. Lighting and power distribution facilities, including busways, main switchboard with metering, transformers, distribution boards, panelboards with feeders, motor control centers, branch circuit wiring, connections to outlets, and wiring devices.
    e. Lighting fixtures and lamps.
    f. Motor and other power-consuming equipment connections from motor control centers or distribution apparatus to equipment.
    g. Telephone and Data conduit system, including underground service facilities, riser and lateral extension conduits, and facilities required in terminal room in accordance with the requirements of the Telephone Utility.
    h. Elevator and escalator feeders.
    i. Control, alarm and interlock wiring for mechanical equipment, where indicated.
    j. Electrical grounding system.
    k. Emergency power and lighting system, including engine-generator set complete with oil system and power transfer capability.
    l. Vibration and seismic controls for electrical systems.
    m. Life safety system including ADA requirements.
    n. Cable tray system.
    o. Low voltage system (PA, CATV, Security, etc.)
    p. Excavation, backfilling and compacting for the Electrical Work.

q. Cutting and patching for the Electrical Work.
r. Adjustment and testing of the Electrical Work.
s. Examine the drawings and specifications of other Divisions and provide electrical service for all equipment, devices and controls noted therein, unless work specifically is not included.
t. Lighting control system.
u. Dimming system.
v. Uninterruptable power supply (UPS) system.
w. Underfloor power and telephone/telecom distribution system.

1.3 DESCRIPTION OF BID DOCUMENTS

A. Specifications:

1. Specifications, in general, describe quality and character of materials and equipment.
2. Specifications are of simplified form and include incomplete sentences.
3. Words or phrases such as "The Contractor shall," "shall be," "furnish," provide," "a," "an," "the," and "all" etc. have been omitted for brevity.

B. Drawings:

1. Electrical layouts are generally diagrammatic and, although size and location of equipment is drawn to scale wherever possible, Contractor shall make use of all data in Contract Documents and verify this information at building site.
2. Locations of items on the drawings may be distorted for purposes of clearness and legibility. Actual locations of architectural and mechanical items are shown on architectural and mechanical drawings.
3. Contractor shall adjust locations of light fixtures in mechanical rooms to compensate for changes in duct routing, to provide reasonably uniform lighting in work areas.
4. Outlets shall be located in accordance with architectural design, and specific locations may be determined by Owner's representative at jobsite prior to installation.
5. Outlets located on architectural plans by dimension shall be held. Additional outlets may be shown on electrical plans and shall be installed as close as practical to the location shown.
6. Manufacturers' drawings and instructions shall be followed in all cases where the makers of devices and equipment furnish directions, where details are not shown on the drawings, or where described in the specifications.
7. Work installed in a manner contrary to that shown in the contract documents shall be removed and reinstalled when so directed by the Architect. Discrepancies and questionable points shall be immediately reported to the Architect for clarification.
8. The Owner and the Architect reserve the right to make reasonable changes in outlet locations in each area prior to roughing-in at no additional cost to the Owner.

C. If any part of specifications or drawings appears unclear or contradictory, apply to Architect for his interpretation and decision as early as possible, including during bidding period. Do not proceed with such work without Architect's decision.

1.4 JOB CONDITIONS

A. Examine all drawings and specifications in a manner to be fully cognizant of all work required under this Division.

B. Adjoining work of other Divisions shall be examined for interferences and conditions affecting this Division.

C. Examine site related work and surfaces before starting work of any Section.
   1. Report to Architect, in writing, conditions which will prevent proper provision of this work.
   2. Beginning work of any Section without reporting unsuitable conditions to Architect constitutes acceptance of conditions by Contractor.
   3. Perform any required removal, repair or replacement of this work caused by unsuitable conditions at no additional cost to Owner.

D. Connections to existing work:
   1. Verification of existing: Before submitting bid, become thoroughly familiar with actual existing conditions and systems at the building, and of the existing installations to which connections must be made, including any necessary alterations, and existing building engineering practices and requirements. The intent of the work is shown on the drawings and described herein, and no consideration will be granted by reason of lack of familiarity on the part of the contractor with actual physical conditions, requirements, and practices at the site.
   2. Install new work and connect to existing work with minimum interference to existing facilities.
   3. Temporary shutdowns of existing services: At times not to interfere with normal operation of existing facilities and only with written approval of the Owner, at no additional charges.
   4. Maintain continuous operation of existing facilities as required with necessary temporary connections between new and existing work. Do not interrupt alarm and emergency systems.
   5. Connect new work to existing work in neat and acceptable manner. Restore existing disturbed work to original condition including maintenance of wiring continuity as required.
   6. Following work shall be performed only after regular working hours:
      a. Power interruption
      b. High Noise level work
      c. X-ray of concrete for coring location verification

E. Removal and Relocation of Existing Work:
   1. Disconnect, remove or relocate electrical material, equipment and other work noted and required by removal or changes in existing construction.
   2. Provide new material and equipment required for relocated equipment.
   3. Disconnect load and supply end of conductors feeding existing equipment.
   4. Remove conductors from existing raceways to be rewired.
   5. Tape both ends of abandoned conductors. Cap outlets and abandoned raceways.
   6. Cut and cap abandoned floor raceways flush with concrete floor or behind walls and ceilings.
   7. Dispose of removed raceways and wire.
   8. Dispose of removed electrical equipment as directed.

F. If asbestos insulation is found when working in existing areas, immediately stop work and notify Architect. Do not restart work until advised in writing by Architect that it is safe to do so following abatement, encapsulation, etc.

1.5 DEFINITIONS

A. “Provide": To furnish, install and connect complete and ready for safe and regular operation of particular work referred to unless specifically otherwise noted.

B. "Install": To erect, mount and connect complete with related accessories.

C. “Furnish” or "Supply": To purchase, procure, acquire and deliver complete with related accessories.

D. "Work": Labor, materials, equipment, apparatus, controls, accessories and other items required for proper and complete installation.

E. "Wiring": Raceway, fittings, wire, boxes and related items.

F. "Concealed": Embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces or in enclosures.

G. "Exposed": Not installed underground or "concealed" as defined above.

H. "Indicated" "Shown" or "Noted": As indicated, shown or noted on drawings or specifications.

I. "Equal": Equal in quality, workmanship, materials, weight, size, design and efficiency of specified product, conforming with "Manufacturers".

J. "Reviewed," "Satisfactory," "Accepted," or "Directed": As reviewed, satisfactory, accepted or directed by or to Architect.

K. "Motor Controllers": Manual or magnetic starters (with or without switches), individual pushbuttons, or hand-off-automatic (HOA) switches controlling the operation of motors.

L. "Control Devices": Automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches and electrodes controlling operation of equipment.

1.6 UTILITY CONNECTIONS

A. Finalize electrical service arrangements including verification of locations and details with the Serving Agency.

B. Verify locations of facilities and details with the Telephone Utility.

1. Final telephone service arrangements will be made by the Owner.

C. In addition to the requirements shown on the drawings and stated herein, the work shall comply with the following:

1. Construction Standards and Service Requirements of the respective utilities including any supplementary drawings issued by the utilities.
2. Be subjected to inspection approval of these utilities.

D. Electrical service facilities shall consist of furnishing and installing concrete encased primary conduits, transformer vault appurtenances and secondary service including utility meter in accordance with the arrangement, details, and locations shown on the drawings and described herein and as required by the utility company.

1. Transformer vault: Furnish and install conduits and ducts with terminations, mounting inserts, lighting fixtures and wiring devices, conduits with outlets, wire with connections for lighting facilities, grounding conductors and fittings and other work as required by the Serving Agency.

1.7 ELECTRICAL SYSTEM CHARACTERISTICS

A. Service: 480/277 volts, 3 phase, 4 wire with grounded neutral.

B. LED Lighting: 277 volts.

C. Motors ½ horsepower and above: 208 volts, 3 phase.

D. Fractional horsepower motors less than ½ horsepower: 120 volts single phase.

E. General receptacles will be supplied at 120 volts.

1.8 MOUNTING HEIGHTS

A. Mounting heights of devices and equipment shown on the architectural drawings shall govern, but in the absence of such indications, the following centerline heights above the finished floor shall be maintained.

1.	Wall switches	3 feet - 6 inches (or as directed by architect).
2.	Wall lights (interior)	7 feet - 0 inches (or as directed by architect).
3.	Pendant or chain hung fixture	10 feet - 0 inches (or as directed by architect).
4.	Convenience receptacles	1 foot - 3 inches except in Toilets and over cabinets or -counters where devices shall be mounted at 4 feet - 0 inches (9 inches above counter).
5.	Fire alarm stations	4 feet - 0 inches.

6.	Telephone and communication outlets	1 foot - 3 inches.
7.	Clock outlets	1 foot - 6 inches below finished ceiling.
8.	Panelboard cabinets	Shall be installed with the top 6 feet - 6 inches above the floor for cabinets more than 2 feet - 6 inches high and 6 feet - 0 inches for cabinets less than 2 feet - 6 inches high.
9.	Motor controllers	5 feet-0 inches.

1.9 SUBMITTALS

A. Submit shop drawings, product data, samples and certificates of compliance required by contract documents.

1. See Submittals paragraph in Division 1.

B. Submit no later than 30 days after signing of Contract:

1. Complete schedule of submittals for equipment and layout shop drawings.
2. Submittals schedule shall be in such sequence as to cause no delay in work or in work of any other division.

C. Corrections or comments made on the shop drawings during review do not relieve the Contractor from compliance with requirements of the drawings and specifications. Shop drawing checking by the Engineer is only for review of general conformance with the design concept of the project and general compliance with the information given in the contract documents. The Contractor is responsible for:

1. Confirming and correlating all quantities and dimensions.
2. Fabrication processes and techniques of construction.
3. Work with all other trades.
4. Work in a safe and satisfactory manner.
5. Equipment that can be installed in the available space with all code clearances, prior to ordering any equipment.

D. Quantity of Submittals Required:

1. Layout Shop Drawings:

a. Submit one reproducible transparency and one print.
b. Upon review, transparency will be annotated and returned. Print will be retained by Engineer.

c. Copies of this transparency will serve as record copies for Architect and Engineer.
d. Additional prints will not be reviewed nor returned.

2. Product data (brochures):

a. Submit six copies of product data.
b. Five copies will be returned.
c. If comments are required, comment sheet(s) will be returned with each copy.
d. One copy will be retained by the Engineer.

3. Samples:

a. Submit as directed by the architect and as required in each specification section.

E. Submittal Format:

1. Number each submittal in consecutive order.
2. Submit minimum one binder for each specific section. Different specification sections shall not be combined within same binder.
3. In each submittal include complete index with the following information:

a. Project title and number.
b. Submittal number.
c. Referenced specification DIVISION, Section, Title, paragraph and page number or drawing reference as applicable and flap each applicable item.
d. Date of submission.
e. Referenced addendum or change order number as applicable.
f. Names of Contractor, supplier and manufacturer.
g. Description of item.
h. Stamp with Contractor's initials or signed certifying:

1) Review of submittal.
2) Verification of products, field measurements and field construction criteria.
3) Coordination of shop drawing and/or information in submittal with requirements of work of this Division and other divisions of Contract Documents.

4. Nomenclature, legend, symbols and abbreviations on submitted material shall be same as used in contract documents.

F. Resubmission Requirements:

1. Make any corrections or change in submittals required. Resubmit only items required for resubmittal for review until no exceptions are taken or a resubmission is not required.

2. Shop Drawings and Product Data:

a. Revise initial drawings or data, and resubmit as specified for initial submittal.

b. Indicate any changes which have been made other than those requested.
c. Provide written response of all previous comments with the resubmittals.

3. Samples: Submit new samples as required for initial submittal.

4. Clearly identify resubmittal by original submittal date, number and revision number and-indicate all changes from previous submittal.

G. Substitutions:

1. In the event of conflict, the provisions of this paragraph shall override those contained in SUBMITTALS and SUBSTITUTIONS paragraphs in DIVISION 1.
2. As a general, substitutions are not acceptable except for hereafter condition:

a. Requests for substitutions shall be considered only in case of product unavailability. Product unavailability shall be verified in writing by manufacturer.
b. Submit separate request for each substitution at appropriate time thereafter in the event of non-availability of item included in bid. Support each request with:

1) Complete data substantiating compliance of proposed substitution with requirements stated in Contract documents.
2) Data relating to changes in construction schedule.
3) Any effect of substitution on other Work in this and other Divisions, and any other related contracts, and changes required in other work or products.

c. Contractor shall be responsible at no extra cost to Owner for any changes resulting from proposed substitutions which affect work of other Sections or Divisions, or related contracts.
d. Substitute products shall not be ordered or installed without prior acceptance by Architect.
e. Architect will have sole discretion to determine acceptability of proposed substitutions and reserves the right to reject any such substitution.
f. Approval of substitutions shall not relieve Contractor from full compliance with requirements of Contract documents.

H. Layout Shop Drawings Required:

1. Prepare and submit following coordinated layout shop drawings on 1/4” scale:

a. Mechanical equipment rooms containing motor control center and/or transformers.
b. All electrical rooms and closets with equipment dimensions.
c. Areas requiring deviations from design documents. Such deviations shall be clearly identified.

2. Layout drawings not varying from design documents shall not be submitted and will not be reviewed.

I. Operating Instructions, Maintenance Manuals and Parts Lists.

1. Before requesting acceptance of work submit one set for review by Architect.
2. After review, furnish five printed and bound sets.
3. Include:

   a. Manufacturer's name, model number, service manual, spare-parts list, and descriptive literature for all components, cross referenced and numbered on Reference Drawings.
   b. Maintenance instructions.
   c. Listing of possible breakdown and repairs.
   d. Instruction for starting, operation and programming.
   e. Detailed and simplified one line and wiring diagrams.
   f. Field test report.
   g. Name, address and phone number of contractors, equipment suppliers and service agencies.
   h. Assemble manufacturer's equipment manuals in chronological order following the specification alpha-numeric system in heavy duty three-ring binders clearly titled on the spine and front cover.

J. Record Drawings:

1. Comply with requirements of Section 01 7839 PROJECT RECORD DOCUMENTS.
2. Submit to Architect for review prior to final acceptance inspection, one complete marked-up set of reproducible drawings.
3. Submit to Architect for review prior to final acceptance inspection, one complete set of reproducible engineering design drawings on electronic files using ACAD and one vellum set.

   a. Fully illustrate all revisions made by all trades.
   b. Include all field changes, adjustments, variances, substitutions and deletions, including all changes made by Change Orders.
   c. Exact location, type and function of all equipment.

4. These drawings shall be for record purposes for Owner's use and are not considered Shop Drawings.

1.9 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
3. To allow right of way for piping and conduit installed at required slope.
4. So that connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."."

PART 2 - PRODUCTS

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. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

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:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Metraflex Co.
d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
3. Pressure Plates: Stainless steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: 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, nonstaining, 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.

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.

F. Layout and installation of electrical work shall be coordinated with the overall construction schedule and work schedules of various trades, to prevent delay in completion of the Project.

1. Complete drawings and specifications for the entire project will be available at the Project site.

2. It shall be obligatory to thoroughly check these drawings before organizing the electrical work schedule, or installing material and equipment.

G. Dimensions and information regarding accurate locations of equipment, and structural limitations and finish shall be coordinated and verified with other Division of Work. Be prepared to promptly furnish dimensions and information regarding electrical Work to other trades and cooperate with them to secure harmony and the best progress of the Project.

H. The drawings do not show off-sets, bends, and special fittings, or junction or pull boxes necessary to meet job conditions. These items shall be provided as required at no additional cost to the Owner.

I. Accessibility and Clearance:

1. Electrical equipment, outlets, junction and pull boxes shall be installed in accessible locations, avoiding obstructions, preserving headroom, and keeping openings and passageways clear.

2. Minor adjustments in the locations of equipment shall be made where necessary, providing such adjustments do not adversely affect functioning of the equipment.

J. Scaffolds and staging for installation of electrical work shall be provided under the work of this Division.

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 (50 mm) above finished floor level.

G. Size pipe sleeves to provide 1/4-inch (6.4-mm) 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 requirements in Division 07 Section "Joint Sealants".

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 requirements in Division 07 Section "Penetration Firestopping."

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 steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) 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. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.5 WEATHERPROOF EQUIPMENT

A. Electrical devices or equipment located in damp, semi-exposed areas shall be weather-resistant. Enclosure shall comply with NEMA Type 3R requirements.

B. Surface mounted outlet boxes shall be cast metal with threaded hubs. Pull or junction boxes shall be cast metal with bolted and gasketed covers.

C. Outlet box covers shall be of a suitable weatherproof type with gaskets, packing glands, weatherproof doors, or other required means to prevent entry of moisture.

D. Lighting fixtures shall be installed with suitable gasket, and UL labeled for location.

3.6 HOUSEKEEPING PADS AND FOUNDATIONS

A. Concrete work required for housekeeping pads and foundations will be provided by General Construction Work. Comply with the requirement for concrete base specified in Division 03 section.
   1. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."
   2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
   3. Install epoxy-coated anchor bolts for anchoring equipment to the concrete base.
   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. Bolt equipment to channel-iron sills embedded in concrete bases. Install sills level and grout flush with floor or base.

6. Refinish damaged or scratched surfaces.
7. Provide 24 inch wide insulating mat in front of operable electrical equipment and in front and rear of free standing ones.
8. Tighten all bolted connections prior to energizing.
9. Provide fuse cabinet with specified number of fuses of each type.
10. Provide special tools as required for routing maintenance and inspection.

B. Furnish required dimensional drawings and specify locations. Minimum height of housekeeping pads shall be 4 inches and shall extend out 6 inches from the footprint of the equipment.

C. Furnish anchor bolts and sleeves, and verify accuracy of installation.

D. Provide for:

1. Switchboards, switchgears, unit substation and floor mounted ATS, MTS.
2. Standby Emergency Generator.
3. Floor mounted transformers.
4. Outdoor light fixture standards.
5. UPS.
6. All other floor mounted equipment.

END OF SECTION 260500

SECTION 260513 - MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes cables and related cable splices, terminations, and accessories for medium-voltage (2001 to 35,000 V) electrical distribution systems.

1.3 DEFINITIONS

A. Jacket: A continuous nonmetallic outer covering for conductors or cables.

B. NETA ATS: Acceptance Testing Specification.

C. Sheath: A continuous metallic covering for conductors or cables.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of cable. Include splices and terminations for cables and cable accessories.

B. Samples: 16-inch (400-mm) lengths for each type of cable specified.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Material Certificates: For each type of cable and accessory.

C. Source quality-control reports.

D. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 FIELD CONDITIONS

A. 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 Architect no fewer than 30 days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Owner's written permission.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Cables:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Aetna Insulated Wire, Inc.
b. General Cable; General Cable Corporation.
c. Kerite Co. (The).
d. Okonite Company (The).
e. Southwire Company.

B. Cables Splicing and Terminating Products and Accessories:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. 3M.
b. Cooper Power Systems, an Eaton business.
c. G&W Electric Company.
d. Raychem; TE Connectivity.
e. Thomas & Betts Corporation, A Member of the ABB Group.

C. Source Limitations: Obtain cables and accessories from single source from single manufacturer.

2.2 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with IEEE C2 and NFPA 70.

2.3 CABLES

A. Cable Type: Type MV 105.

B. Comply with UL 1072, AEIC CS8, ICEA S-93-639/NEMA WC 74, and ICEA S-97-682, and ICEA S-94-649.

C. Conductor: Copper.

D. Conductor Stranding: Concentric lay, Class B.

E. Strand Filling: Conductor interstices are filled with impermeable compound.

F. Conductor Insulation: Crosslinked polyethylene.

1. Voltage Rating: 15 kV.
2. Insulation Thickness: 133 percent insulation level.

G. Shielding: Solid copper wires, helically applied over semiconducting insulation shield.

H. Shielding and Jacket: Corrugated copper drain wires embedded in extruded, chlorinated, polyethylene jacket.

I. Three-Conductor Cable Assembly: Three insulated, shielded conductors cabled together with ground conductors.

1. Circuit Identification: Color-coded tape (black, red, blue) under the metallic shielding.

J. Cable Sheath: Interlocked galvanized steel applied over cable.

K. Cable Jacket: Sunlight-resistant PVC.

2.4 CONNECTORS

A. Comply with ANSI C119.4 for connectors between aluminum conductors or for connections between aluminum to copper conductors.

B. Copper-Conductor Connectors: Copper barrel crimped connectors.

2.5 SOLID TERMINATIONS

A. Multiconductor Cable Sheath Seals: Type recommended by seal manufacturer for type of cable and installation conditions, including orientation.

1. Compound-filled, cast-metal-body, metal-clad cable terminator for metal-clad cable with external plastic jacket.
2. Cold-shrink sheath seal kit with preformed sleeve openings sized for cable and insulated conductors.
3. Heat-shrink sheath seal kit with phase- and ground-conductor rejacketing tubes, cable-end sealing boot, and sealing plugs for unused ground-wire openings in boot.

4. Cast-epoxy-resin sheath seal kit with wraparound mold and packaged, two-part, epoxy-resin casting material.

B. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class shall be equivalent to that of cable. Include shield ground strap for shielded cable terminations.

1. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone-rubber, insulator modules; shield ground strap; and compression-type connector.
2. Class 1 Terminations: Heat-shrink type with heat-shrink inner stress control and outer nontracking tubes; multiple, molded, nontracking skirt modules; and compression-type connector.
3. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief shield terminator; multiple-wet-process, porcelain, insulator modules; shield ground strap; and compression-type connector.
4. Class 1 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, compression-type connector, and end seal.
5. Class 2 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, and compression-type connector. Include silicone-rubber tape; cold-shrink-rubber sleeve; or heat-shrink, plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.
6. Class 3 Terminations: Kit with stress cone and compression-type connector.

2.6 SEPARABLE INSULATED CONNECTORS

A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.

B. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.

C. Load-Break Cable Terminators: Elbow-type units with 200-A-load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

D. Dead-Break Cable Terminators: Elbow-type unit with 200-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

E. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.

1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.

3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.
4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.

F. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.

G. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

2.7 SPLICE KITS

A. Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for the application.

B. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, materials, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.

1. Combination tape and cold-shrink-rubber sleeve kit with rejacketing by cast-epoxy-resin encasement or other waterproof, abrasion-resistant material.
2. Heat-shrink splicing kit of uniform, cross-section, polymeric construction with outer heat-shrink jacket.
3. Premolded, cold-shrink-rubber, in-line splicing kit.
4. Premolded, EPDM splicing body kit with cable joint sealed by interference fit of mating parts and cable.
5. Separable multiway splice system with all components for the required splice configuration.

2.8 MEDIUM-VOLTAGE TAPES

A. Ethylene/propylene rubber-based, 30-mil (0.76-mm) splicing tape, rated for 130 deg C operation. Minimum 3/4 inch (20 mm) wide.

B. Silicone rubber-based, 12-mil (0.30-mm) self-fusing tape, rated for 130 deg C operation. Minimum 1-1/2 inches (38 mm) wide.

C. Insulating-putty, 125-mil (3.175-mm) elastic filler tape. Minimum 1-1/2 inches (38 mm) wide.

2.9 ARC-PROOFING MATERIALS

A. Tape for First Course on Metal Objects: 10-mil- (250-micrometer-) thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.

B. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch (8 mm) thick, and compatible with cable jacket.

C. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1 inch (25 mm) wide.

2.10 FAULT INDICATORS

A. Indicators: Automatically reset fault indicator with inrush restraint feature, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.

B. Resetting Tool: Designed for use with fault indicators, with moisture-resistant storage and carrying case.

2.11 SOURCE QUALITY CONTROL

A. Test and inspect cables according to ICEA S-97-682 before shipping.

B. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig (35 kPa).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cables according to IEEE 576.

B. Proof conduits prior to conductor installation by passing a wire brush mandrel and then a rubber duct swab through the conduit. Separate the wire brush and the rubber swab by 48 to 72 inches (1200 to 1800 mm) on the pull rope.

1. Wire Brush Mandrel: Consists of a length of brush approximately the size of the conduit inner diameter with stiff steel bristles and an eye on each end for attaching the pull ropes. If an obstruction is felt, pull the brush back and forth repeatedly to break up the obstruction.
2. Rubber Duct Swab: Consists of a series of rubber discs approximately the size of the conduit inner diameter on a length of steel cable with an eye on each end for attaching the pull ropes. Pull the rubber duct swab through the duct to extract loose debris from the duct.

C. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

1. Where necessary, use manufacturer-approved pulling compound or lubricant that does not deteriorate conductor or insulation.

2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips, that do not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
3. Use pull-in guides, cable feeders, and draw-in protectors as required to protect cables during installation.
4. Do not pull cables with ends unsealed. Seal cable ends with rubber tape.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

E. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

F. Install direct-buried cables on leveled and tamped bed of 3-inch- (75-mm-) thick, clean sand. Separate cables crossing other cables or piping by a minimum of 2 inches (50 mm) of tamped earth, plus an additional 2 inches (50 mm) of sand. Install permanent markers at ends of cable runs, changes in direction, and buried splices.

G. Install "buried-cable" warning tape 12 inches (305 mm) above cables.

H. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit; support cables at intervals adequate to prevent sag.

I. Install sufficient cable length to remove cable ends under pulling grips. Remove length of conductor damaged during pulling.

J. Install cable splices at pull points and elsewhere as indicated; use standard kits. Use dead-front separable watertight connectors in manholes and other locations subject to water infiltration.

K. Install terminations at ends of conductors, and seal multiconductor cable ends with standard kits.

L. Install separable insulated-connector components as follows:

1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
2. Portable Feed-Through Accessory: At each terminal junction, with one on each terminal.
3. Standoff Insulator: At each terminal junction, with one on each terminal.

M. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:

1. Clean cable sheath.
2. Wrap metallic cable components with 10-mil (250-micrometer) pipe-wrapping tape.
3. Smooth surface contours with electrical insulation putty.
4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
5. Band arc-proofing tape with two layers of 1-inch- (25-mm-) wide half-lapped, adhesive, glass-cloth tape at each end of the arc-proof tape.

N. Seal around cables passing through fire-rated elements according to Section 078413 "Penetration Firestopping."

O. Install fault indicators on each phase where indicated.

P. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.

Q. Ground shields of shielded cable at one point only. Maintain shield continuity and connections to metal connection hardware at all connection points.

R. Identify cables according to Section 260553 "Identification for Electrical Systems." Identify phase and circuit number of each conductor at each splice, termination, pull point, and junction box. Arrange identification so that it is unnecessary to move the cable or conductor to read the identification.

3.2 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. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
3. Perform direct-current High Potential test of each new conductor according to NETA ATS, Ch. 7.3.3. Do not exceed cable manufacturer's recommended maximum test voltage.
4. Perform Partial Discharge test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.
5. Perform Dissipation Factor test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.

D. Medium-voltage cables will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 260513

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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:

1. Section 260513 "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 2001 to 35,000 V.
2. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2 and 3 control cables.
3. Section 271500 "Communications Horizontal Cabling" for cabling used for voice and data circuits.

1.3 DEFINITIONS

A. VFC: Variable frequency controller.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Belden Inc.
2. Cooper Industries, Inc.
3. General Cable Technologies Corporation.
4. General Cable; General Cable Corporation.
5. Southwire Company.
6. Thomas & Betts Corporation, A Member of the ABB Group.

B. Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.

C. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN/THWN-2.

D. 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. Comply with UL requirements for cables in Classes I and II, Division 2 hazardous location applications.

2.2 CONNECTORS AND SPLICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. 3M.
2. AFC Cable Systems; a part of Atkore International.
3. Hubbell Power Systems, Inc.
4. ILSCO.
5. O-Z/Gedney; a brand of Emerson Industrial Automation.
6. TE Connectivity Ltd.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. 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, except VFC cable, which shall be extra flexible stranded.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-2, single conductors in raceway.

B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

E. Feeders in Cable Tray: Type THHN/THWN-2, single conductors in raceway.

F. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.

H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

I. Branch Circuits in Cable Tray: Type THHN/THWN-2, single conductors in raceway.

J. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

K. VFC Output Circuits: Type TC-ER cable with dual tape shield.

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 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

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."

G. Complete cable tray systems installation according to Section 260536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

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 12 inches (300 mm) 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 according to Section 078413 "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections 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 and conductors feeding the following critical equipment and services for compliance with requirements.

    a. Generator

    b. ATS

    c. UPS

    d. Maintenance bypass

2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

    a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
    b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

D. Test and Inspection Reports: Prepare a written report to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

E. Cables will be considered defective if they do not pass tests and inspections.

END OF SECTION 260519

SECTION 260523 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Low-voltage control cabling.
   2. Control-circuit conductors.
   3. Identification products.

1.3 DEFINITIONS

A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.

B. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.

B. Source quality-control reports.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

PART 2 - PRODUCTS

2.1 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.

2.2 PERFORMANCE REQUIREMENTS

A. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262 by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.

1. Flame Travel Distance: 60 inches (1520 mm) or less.
2. Peak Optical Smoke Density: 0.5 or less.
3. Average Optical Smoke Density: 0.15 or less.

B. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.

C. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

2.3 LOW-VOLTAGE CONTROL CABLE

A. Paired Cable: NFPA 70, Type CMG.

1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1685.

B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

2.4 CONTROL-CIRCUIT CONDUCTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Encore Wire Corporation.
2. General Cable; General Cable Corporation.

3. Service Wire Co.
4. Southwire Company.

B. Class 1 Control Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway, complying with UL 83.

C. Class 2 Control Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway, complying with UL 83.

D. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway, complying with UL 83.

E. Class 2 Control Circuits and Class 3 Remote-Control and Signal Circuits That Supply Critical Circuits: Circuit Integrity (CI) cable.

1. Generator start signal.
2. Generator breaker position.
3. Emergency breaker position.

2.5 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Cable will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Test cables on receipt at Project site.

1. Test to determine the continuity free of open or shorted connections.

3.2 INSTALLATION OF RACEWAYS AND BOXES

A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or modified in this Section.

1. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.
2. Flexible metal conduit shall not be used.

B. Install manufactured conduit sweeps and long-radius elbows if possible.

C. Raceway Installation in Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard if entering the room from overhead.
4. Extend conduits 6 inches (150 mm) above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1 and NFPA 70.

B. General Requirements for Cabling:
1. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
2. Cables may not be spliced.
3. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
4. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
5. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Monitor cable pull tensions.
6. Support: Do not allow cables to lay on removable ceiling tiles.
7. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.

C. Installation of Control-Circuit Conductors:

1. Install wiring in raceways. Comply with requirements specified in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 REMOVAL OF CONDUCTORS AND CABLES

A. Remove abandoned conductors and cables. Abandoned conductors and cables are those installed that are not terminated at equipment and are not identified for future use with a tag.

3.5 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits; No 14 AWG.
2. Class 2 low-energy, remote-control, and signal circuits; No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm, and signal circuits; No 12 AWG.

3.6 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

3.7 GROUNDING

A. For low-voltage control wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.8 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.9 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. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

D. End-to-end cabling will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 260523

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 grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

A. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:

1. Test wells.
2. Ground rods.
3. Ground rings.
4. Grounding arrangements and connections for separately derived systems.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Instructions for periodic testing and inspection of grounding features at test wells, ground rings and grounding connections for separately derived systems based on NFPA 70B.

1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
2) Include recommended testing intervals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Burndy; Part of Hubbell Electrical Systems.
2. ERICO International Corporation.
3. ILSCO.
4. O-Z/Gedney; a brand of Emerson Industrial Automation.
5. Thomas & Betts Corporation, A Member of the ABB Group.

2.2 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.3 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches (6.3 by 100 mm) in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart, unless specified in the drawing. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.5 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet (19 mm by 3 m).

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 (1200 mm) long.
2. Backfill Material: Electrode manufacturer's recommended material.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum.

1. Bury at least 24 inches (600 mm) below grade.
2. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.

C. 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 (50 mm) minimum from wall, 6 inches (150 mm) 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.

D. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Generator: Install grounding electrode(s), ground rod and ground ring, at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) 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 (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, non-shrink 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 (150 mm) from the foundation.

3.5 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater Cables: Install a separate insulated equipment grounding conductor to each electric water heater. Bond conductor to heater units, piping, connected equipment, and components.

E. 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.

F. Metallic Fences: Comply with requirements of IEEE C2.

1. Grounding Conductor: Bare copper, not less than No. 8 AWG.
2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.6 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Rods: Drive rods until tops are 2 inches (50 mm) 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.

C. 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 (300 mm) 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.

D. 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.

E. 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 exterior metallic 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.

F. 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.

G. 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 (18 m) apart.

H. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building.

1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
2. Bury ground ring not less than 24 inches (600 mm) from building's foundation.

I. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 AWG.

1. If concrete foundation is less than 20 feet (6 m) 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.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

E. Grounding system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm.
5. Substations and Pad-Mounted Equipment: 5 ohms.
6. Manhole Grounds: 10 ohms.

H. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

B. Related Requirements:

1. Section 260548.16 "Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

a. Hangers.
b. Steel slotted support systems.
c. Nonmetallic support systems.
d. Trapeze hangers.
e. Clamps.
f. Turnbuckles.
g. Sockets.
h. Eye nuts.
i. Saddles.
j. Brackets.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. For fabrication and installation details for electrical hangers and support systems.

1. Trapeze hangers. Include product data for components.
2. Steel slotted-channel systems.
3. Nonmetallic slotted-channel systems.

4. Equipment supports.
5. 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.

C. Delegated-Design Submittal: For hangers and supports for electrical systems.

1. Include design calculations and details of trapeze hangers.
2. Include design calculations for seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which hangers and supports will be attached.
3. Size and location of initial access modules for acoustical tile.
4. Items penetrating finished ceiling, including the following:

a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Projectors.

B. Seismic Qualification Certificates: For hangers and supports for electrical equipment and systems, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M.
2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

C. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D 635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Allied Tube & Conduit; a part of Atkore International.
b. B-line, an Eaton business.
c. ERICO International Corporation.
d. Thomas & Betts Corporation, A Member of the ABB Group.
e. Unistrut; Part of Atkore International.

2. Material: Galvanized steel.

3. Channel Width: 1-5/8 inches (41.25 mm).
4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
6. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
8. Channel Dimensions: Selected for applicable load criteria.

B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

        1) Hilti, Inc.
        2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
        3) MKT Fastening, LLC.
        4) Simpson Strong-Tie Co., Inc.

2. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

        1) B-line, an Eaton business.
        2) Empire Tool and Manufacturing Co., Inc.
        3) Hilti, Inc.
        4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
        5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.

4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems unless requirements in this Section are stricter.

B. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMTs, IMCs, and RMCs may be supported by openings through structure members, according to NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.

3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
6. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base as follows:

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Comply with requirements in Section 099113 "Exterior Painting" Section 099123 "Interior Painting" and Section 099600 "High-Performance Coatings" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529

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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.
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. GRC: Galvanized rigid steel conduit.

B. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

C. Samples: For wireways, nonmetallic wireways and surface raceways and for each color and texture specified, 12 inches (300 mm) long.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Qualification Data: For professional engineer.

C. Seismic Qualification Certificates: For enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.

D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AFC Cable Systems; a part of Atkore International.
2. Allied Tube & Conduit; a part of Atkore International.
3. O-Z/Gedney; a brand of Emerson Industrial Automation.
4. Southwire Company.
5. Thomas & Betts Corporation, A Member of the ABB Group.
6. Western Tube and Conduit Corporation.
7. Wheatland Tube Company.

B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. IMC: Comply with ANSI C80.6 and UL 1242.

E. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch (1 mm), minimum.

F. EMT: Comply with ANSI C80.3 and UL 797.

G. FMC: Comply with UL 1; zinc-coated steel or aluminum.

H. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

I. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
2. Fittings for EMT:

   a. Material: Steel or die cast.
   b. Type: Setscrew for branch circuits and compression for feeders.

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 (1 mm), with overlapping sleeves protecting threaded joints.

J. Joint Compound for IMC, GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AFC Cable Systems; a part of Atkore International.
2. Anamet Electrical, Inc.
3. RACO; Hubbell.
4. Thomas & Betts Corporation, A Member of the ABB Group.

B. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ENT: Comply with NEMA TC 13 and UL 1653.

D. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

E. LFNC: Comply with UL 1660.

F. Rigid HDPE: Comply with UL 651A.

G. Continuous HDPE: Comply with UL 651B.

H. Coilable HDPE: Preassembled with conductors or cables, and complying with ASTM D 3485.

I. RTRC: Comply with UL 1684A and NEMA TC 14.

J. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

K. Fittings for LFNC: Comply with UL 514B.

L. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

M. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. B-line, an Eaton business.
2. Hoffman; a brand of Pentair Equipment Protection.
3. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 Type 4 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 or Flanged-and-gasketed type as applicable unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.4 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Allied Moulded Products, Inc.
2. Hoffman; a brand of Pentair Equipment Protection.
3. Niedax Inc.

B. Listing and Labeling: Nonmetallic wireways and auxiliary gutters shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Description: Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover shall be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections shall be flanged and have stainless-steel screws and oil-resistant gaskets.

D. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.

E. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.

F. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

G. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.5 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Hubbell Incorporated; Wiring Device-Kellems.
    b. MonoSystems, Inc.
    c. Panduit Corp.
    d. Wiremold / Legrand.

C. Surface Nonmetallic Raceways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors. Product shall comply with UL 94 V-0 requirements for self-extinguishing characteristics.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Hubbell Incorporated.
    b. MonoSystems, Inc.

c. Panduit Corp.
d. Wiremold / Legrand.

D. Tele-Power Poles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. MonoSystems, Inc.
b. Panduit Corp.
c. Wiremold / Legrand.

2. Material: Galvanized steel with ivory baked-enamel finish.

3. Fittings and Accessories: Dividers, end caps, covers, cutouts, wiring harnesses, devices, mounting materials, and other fittings shall match and mate with tele-power pole as required for complete system.

2.6 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Crouse-Hinds, an Eaton business.
2. EGS/Appleton Electric.
3. Hoffman; a brand of Pentair Equipment Protection.
4. Hubbell Incorporated.
5. O-Z/Gedney; a brand of Emerson Industrial Automation.
6. RACO; Hubbell.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

F. Metal Floor Boxes:

1. Material: Sheet metal.
2. Type: Fully adjustable.
3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Nonmetallic Floor Boxes: Nonadjustable, rectangular.

1. Listing and Labeling: Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) 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 (32 kg).

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, 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 (100 mm square by 60 mm deep).

N. Gangable boxes are allowed.

O. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1, Type 4 with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures: Fiberglass.
3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

P. Cabinets:

1. NEMA 250, Type 1 Type 3R galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.7 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Armorcast Products Company.
   b. Carson Industries LLC.
   c. Oldcastle Precast, Inc.
   d. Synertech Moulded Products.

2. Standard: Comply with SCTE 77.
3. Configuration: Designed for flush burial with integral closed bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, "ELECTRIC.".
7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes 12 Inches Wide by 24 Inches Long (300 mm Wide by 600 mm Long) and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.8 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
1. 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.
2. 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: GRC RNC, Type EPC-40-PVC.
2. Concealed Conduit, Aboveground: GRC RNC, Type EPC-40-PVC.

3. Underground Conduit: RNC, Type EPC-40-PVC, concrete encased.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:

    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.
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: IMC.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 3/4-inch (21-mm) 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 for branch circuits and compression for feeders, steel 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 (49 deg C).

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 (150 mm) 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 (300 mm) 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 (300 mm) of enclosures to which attached.

I. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot (3-m)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 (50 mm) of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
5. Change from ENT to 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 (35mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) 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 (53-mm) 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 (90-kg) tensile strength. Leave at least 12 inches (300 mm) 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 (50-mm) radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

T. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

U. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Where otherwise required by NFPA 70.

V. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

W. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C) and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC and EMT conduit that is located

where environmental temperature change may exceed 100 deg F (55 deg C) and that has straight-run length that exceeds 100 feet (30 m).

2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
    d. Attics: 135 deg F (75 deg C) temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F (0.0115 mm per meter of length of straight run per deg C) of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

X. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches (1830 mm) of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

Y. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

Z. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

AA. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

BB. Locate boxes so that cover or plate will not span different building finishes.

CC. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

DD. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

EE. Set metal floor boxes level and flush with finished floor surface.

FF. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.
2. Install backfill as specified in Section 312000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete for a minimum of 12 inches (300 mm) on each side of the coupling.
    b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

5. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried conduits but a minimum of 6 inches (150 mm) below grade. Align planks along centerline of conduit.
6. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.

D. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.

E. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.7 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

SECTION 260539 - UNDERFLOOR RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Flat-top, single- or multichannel, underfloor raceways.
2. Flush, flat-top underfloor raceways.
3. Supports, raceway fittings, and hardware.
4. Junction boxes.
5. Service fittings.

1.3 DEFINITIONS

A. Activation: Nomenclature used by some manufacturers for a service fitting.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include finishes, construction details, material descriptions, dimensions, and profiles for underfloor raceway components, fittings, and accessories.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For underfloor raceways.

1. Include floor plans, elevations, sections, and details.
2. Detail fabrication and assembly of underfloor raceways.

a. Identify components and accessories, such as expansion-joint assemblies, straight raceway lengths, preset and afterset inserts, and service fittings.
b. Detail preparation and installation methods and instructions.
c. Provide dimensions locating raceway header and distribution elements. Include spacing between preset inserts and between preset inserts and ends of duct runs, walls, columns, junction boxes, and header duct connections.
d. Provide raceway fill charts for each duct size provided for each conductor size the duct is identified to accept. Provide separate charts for power and communication conductors and cables.

e. Show connections between raceway elements and relationships between components and adjacent structural and architectural elements, including slab reinforcement, floor finish work, permanent partitions, expansion joints, and architectural module lines.
f. Indicate height of preset inserts, junction boxes, and raceways coordinated with depth of concrete slab and floor fill.
g. Indicate thickening of slabs where required for adequate encasement of raceway components.
h. Document coordination of exposed components with floor-covering materials to ensure that fittings and trim are suitable for indicated floor-covering material.
i. Revise locations from those indicated in the Contract Documents, as required to suit field conditions and to ensure a functioning layout. Identify proposed deviations from the Contract Documents.
j. Show details of connections and terminations of underfloor raceways at panelboards and communication terminal equipment in equipment rooms, wire closets, and similar spaces.

C. Samples: For each underfloor raceway product, in specified finish, including the following:

1. Service fittings and flush and recessed outlet and junction-box covers.
2. A section of each service raceway configuration, with specified preset insert and service fitting installed.
3. A junction box of each size and type for use with underfloor raceway.
4. A section of each header raceway configuration, complete with provisions for connection with service raceway.
5. A section of trench-type raceway, complete with cover and required trim.
6. A junction box of each size and type for use with trench-type raceway, complete with cover and trim.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For underfloor raceways, to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Manufacturer's written instructions for locating preset inserts and for installing afterset inserts.

B. Project Record Documents: Submit final as-built Drawings, indicating dimensioned locations for all ducts, junction boxes, and preset inserts. Typical spacing designation shall be accepted only for preset insert spacing along a continuous length of duct.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Afterset Inserts: Furnish quantity equal to 10 percent of service fittings installed.
2. Afterset Inserts: Furnish quantity equal to 5 percent of each type of preset insert installed.
3. Service Fittings: Furnish three of each type of service fitting indicated for each 100 feet (30 m) of distribution raceway or active-floor-cell length.
4. Outlet Blanking Covers: Furnish quantity equal to 10 percent of each type of floor opening installed for outlets.

B. Furnish one electronic instrument(s) and other tools, as recommended by underfloor raceway manufacturer for detecting, locating, and uncovering preset inserts in metal raceway under floor covering and up to 3/8 inch (10 mm) of concrete fill.

C. Furnish one set(s) of tools needed for installing afterset inserts in underfloor service raceway, including the following:

1. Electric Drill: Variable speed, 1/2-inch (13-mm) capacity.
2. Hole Saw: Diamond bit, for dry concrete, 2-inch (50-mm) size.
3. Insert installation tool.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Comply with UL 884.

C. Comply with NFPA 70.

D. Mockup: Install a mockup for evaluation of surface preparation and duct installation techniques and workmanship.

1. Mockup area shall be designated by Architect.
2. Do not proceed with remaining work until workmanship, appearance, and performance are approved.
3. Repair or reinstall mockup area as required to produce acceptable work.
4. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
5. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

PART 2 - PRODUCTS

2.1 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.

2.2 FLAT-TOP, STEEL UNDERFLOOR RACEWAYS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. MonoSystems, Inc.
2. Square D.
3. Thomas & Betts Corporation, A Member of the ABB Group.
4. Walker Systems, Inc.

B. Source Limitations: Obtain underfloor raceway components for each system through single source from single manufacturer.

C. Description:

1. Material: One-piece, continuous weld, minimum 0.0598-inch- (1.5-mm-) thick steel, with galvanized coating inside and out after welding.
2. Cross-Section Shape: Rectangular, with rounded corners.
3. Number of Longitudinal Channels: Two, separated by steel wall(s).
4. Number of Levels: One.
5. Minimum Bending Radius for Communication Cables: Combination of raceways, fittings, inserts, junction boxes, service fittings, and mounting and connection arrangements for wiring devices and jacks shall provide a 2-inch- (50-mm-) minimum bending radius for communication cables.

D. Service Raceways: Fitted with preset inserts.

1. Nominal Multichannel Underfloor Raceway Dimensions:

a. Depth: 1-3/8 inches (35 mm).
b. Power Service Channel Width: 3-1/2 inches (88 mm).
c. Communication Service Channel Width: 6 inches (150 mm).

2. Nominal Single-Channel Underfloor Raceway Dimensions:

a. Depth: 1-1/2 inches (38 mm).
b. Power Service Raceway Width: 3-1/4 inches (81 mm).
c. Communication Service Raceway Width: 6 inches (150 mm).
d. Number of Single-Channel Raceways per Run: Two, unless otherwise indicated.

3. Preset Inserts: Rectangular.

a. Spacing: 12 inches (300 mm) o.c.
b. Size: Rectangular dimensions as required to accommodate mounting and connection of flush- and surface-mounted, single- and multiple-outlet service fittings or to connect to wiring extensions for feeding wall outlets for power and communications.
c. Equip each insert with a disposable cover, and select insert height so cover is 1/8 inch (3 mm) below surface of concrete.
d. Arrange insert for optional attachment of flush-, surface-, or wiring-extension service fitting to replace disposable cover. Arrange brackets, mountings, barriers, and floor access covers to support, isolate, and provide access to flush or surface outlet-mounting connector, jack, and receptacle devices.

E. Header Raceways: Multichannel, without preset inserts (blank raceway).

1. Nominal Raceway Dimensions:

a. Depth: Same as service raceways.

2. Arrangement: Below service raceways.
3. Connections: Arranged to connect with service raceways at single-level junction boxes.

2.3 FLUSH, FLAT-TOP UNDERFLOOR RACEWAYS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Walker Systems, Inc.

B. Source Limitations: Obtain underfloor raceway components for each system through single source from single manufacturer.

C. Description:

1. Material: Steel.
2. Cross-Section Shape: Rectangular, single channel and multichannel, separated by steel wall(s).
3. Listed and labeled for installation with top flush with concrete floor.
4. Number of Levels: One.

D. Service Raceways: Fitted with preset inserts.

1. Number of Longitudinal Channels per Multichannel Raceway: Two.
2. Number of Single-Channel Raceways per Run: Two unless otherwise indicated.
3. Nominal Channel Dimensions: 3 inches (75 mm) wide by 1-1/4 inches (31 mm) deep.
4. Preset Inserts: Threaded opening with removable steel plug that is flush with top of raceway when screwed in place.

a. Spacing: 12 inches (300 mm) o.c., full length of each service raceway.
b. Arrangement: Stagger insert locations on parallel raceways or channels to accommodate placement of adjacent service fittings.
c. Size: 1-5/8-inch (41-mm) diameter.

E. Trench Duct Crossunder: Fitting attached to underside of trench duct.

1. Nominal Channel Dimensions: Same as service raceways.
2. Arrangement: Offset by depth of trench duct.
3. Connections: Arranged to connect trench duct to flush duct through factory-cut, grommeted openings.

F. Header Raceways: Raceways same as service raceways, except without preset inserts (blank raceway).

1. Nominal Channel Dimensions: Same as service raceways.
2. Arrangement: In same plane as service raceways.
3. Connections: Arranged to connect with service raceways at junction boxes.

2.4 SUPPORTS, RACEWAY FITTINGS, AND HARDWARE

A. Source Limitations: Obtain underfloor raceway supports, fittings, and hardware components for each system through single source from single manufacturer.

B. Supports, fittings, and hardware shall be compatible with raceway and outlet system and shall be listed for use with raceway systems and components delivered.

C. Supports: Adjustable for height and arranged to maintain alignment and spacing of raceways during concrete placement. Include hold-down straps.

D. Raceway Fittings: Couplings, expansion-joint sleeves, cross-under offsets, vertical and horizontal elbows, grounding screws, adapters, end caps, and other fittings suitable for use with basic components to form a complete installation.

2.5 JUNCTION BOXES

A. Description: Raceway manufacturer's standard enclosure for indicated type, quantity, arrangement, and configuration of raceways at each raceway junction, intersection, and access location. Include the following accessories and features:

1. Mounting brackets.
2. Escutcheons and holders to accommodate surrounding floor covering.
3. Means for leveling and height adjustment more than 3/8 inch (10 mm) before and after concrete is placed.
4. Boxes shall withstand a minimum 300-lb (136-kg) concentrated load. Internal supports shall be provided as needed to meet this requirement.
5. All boxes shall provide 2-inch- (**50**-mm-) minimum bend radius for data and communication cables.
6. Raceway Openings: For underfloor raceways and conduits arranged to accommodate raceway layout.
7. Covers shall have appropriate depth recess to receive specific floor finish material.
8. Partitions to separate wiring of different systems.

2.6 SERVICE FITTINGS/ACTIVATIONS

A. Source Limitations: Obtain underfloor raceway service fittings and hardware for each system through single source from single manufacturer.

B. Exposed Parts Finish: Brushed aluminum, unless otherwise noted by Architect. Confirm with Architect for final finish.

C. Flush, Single-System Service Fitting for Round Inserts: Include mounting and cover to support and provide access to single connector, jack, or receptacle device; mounted flush with floor within body of insert.

1. Connector, Jack, and Receptacle Devices: Single modular type; complying with Section 262726 "Wiring Devices".
2. Power Receptacle Outlet: Suitable for 20-A, 120-V device.

D. Flush, Single- or Multiple-System Service Fitting for Rectangular Inserts: Include mounting, hinged cover, and trim to support and provide access to connector, jack, or receptacle devices mounted flush with floor within insert.

1. Connector, Jack, and Receptacle Devices: Modular type; complying with Section 262726 "Wiring Devices" and Section 271500 "Communications Horizontal Cabling."
2. Power Receptacle Rating: 20 A, 120 V unless otherwise indicated.
3. Recess-Mounted Service Fitting: Modular fittings compatible with preset inserts. Include device plates for indicated systems and provisions for receptacles, jacks, and connectors. Include hinged flush covers with recessed depth to match thickness of floor finish material. Provide for internally mounted receptacle- and communication-jack and connector assemblies complying with requirements in Section 262726 "Wiring Devices" and Section 271500 "Communications Horizontal Cabling."

    a. Duplex receptacle.
    b. Duplex telephone-data jacks.
    c. Double duplex receptacles.
    d. Duplex receptacle and duplex telephone-data jacks.
    e. Double duplex telephone-data jacks, Category 6.

E. Surface-Mounted Service Fitting: Modular pedestal type, with locking attachment matched to insert floor opening.

1. Power-outlet, double-faced, surface-mounted unit for duplex receptacle on both sides.
2. Power-outlet, single-faced, surface-mounted unit for duplex receptacle on one side.
3. Communication-outlet, double-faced, surface-mounted unit.

    a. Include bushed openings on both sides; 1-inch (25-mm) minimum diameter; insulated with nonconducting material.
    b. Include provisions for modular dual fiber-optic connector assembly on both sides.
    c. Include provisions for modular dual jack-connector assembly, rated for Category 6 on both sides.

4. Communication-outlet, single-faced, surface-mounted unit with bushed opening on one side; 1-inch (25-mm) minimum diameter; insulated with nonconducting material.

5. Combination surface-mounted unit for duplex receptacle on one side and with communication cable connection provision on opposite side.

    a. Communication Side: Include bushed opening; 1-inch (25-mm) minimum diameter; insulated with nonconducting material.
    b. Communication Side: Include provisions for modular dual fiber-optic connector assembly.
    c. Communication Side: Include provisions for modular dual jack-connector assembly, rated for Category 6.

6. Flush-Mounted Service Fittings: Modular fittings compatible with preset inserts and shall include covers, provisions for receptacles jacks and connector assemblies and wiring extensions to wall-mounted outlets, and associated device plates for indicated systems. Include flush covers, recessed to suit floor finish material. Internally mounted, modular, receptacle, jack and connector assemblies shall comply with requirements in Section 262726 "Wiring Devices" and Section 271500 "Communications Horizontal Cabling."
7. Coordinate with Section 262726 "Wiring Devices" and Section 271500 "Communications Horizontal Cabling," and indicate types and locations of devices on Drawings.

    a. Duplex convenience receptacle.
    b. Duplex telephone-data outlets.
    c. Double duplex convenience receptacles.
    d. Duplex convenience receptacle and duplex telephone-data outlets.
    e. Double duplex telephone-data outlets.
    f. Duplex communication jack, rated for Category 6.
    g. Duplex fiber-optic communication connector.
    h. Wiring-Extension Service Fittings: Arrangement of brackets and mountings to support and provide access to wiring or cabling of a cell, and to connect the cable or raceway that extends the system to an individual wall outlet. Provide for connection of FMC for power extensions, and FMC for communication system extensions.

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

3.2 INSTALLATION

A. Install raceways aligned and leveled and, unless otherwise indicated, parallel or perpendicular to floor supports.

B. Maintain arrangement of conductor services throughout the raceway system.

C. Arrange supports to attain proper elevation, alignment, and spacing of raceways. Fasten supports securely at ends and at intervals not to exceed 60 inches (1500 mm), to prevent movement during concrete pour.

D. Level raceway components with finished slab and make adjustments in raceway component elevation to accommodate indicated floor finishes.

E. Junction Boxes: Install tops level and flush with finished floor. Install blank closure plates or plugs to close unused junction-box openings. Grout boxes in place to prevent movement during construction. Place top covers in inverted position during construction to prevent damage to surface of cover. Reinstall covers in proper position prior to final acceptance of the Work.

F. Install preset inserts per manufacturer's instructions.

G. Adjust supports to maintain a 1/8- to 3/8-inch (3.0- to 10-mm) finished concrete cover over preset inserts.

H. Remove burrs, sharp edges, dents, and mechanical defects.

I. Cap or plug boxes, insert- and service-fitting openings, and open ends of raceways.

J. Install expansion fittings with suitable bonding jumper where raceways cross building expansion joints.

K. Bond underfloor raceway components to create a continuous bonding path.

L. Seal raceways, cells, junction boxes, and inserts to prevent water, concrete, or foreign matter from entering raceways before and during pouring slab or placing fill. Tape joints or seal with compound, as recommended in writing by underfloor raceway manufacturer.

M. Install a marker at the center of the last insert of each cell and channel of each straight run of metal underfloor service raceway to locate the insert and identify the system.

1. Install markers at last inserts on both sides of permanent walls and at first inserts adjacent to each junction box.
2. Install markers flush at screed line before pouring slab or placing fill. Extend marker with grommeted screw when floor covering is placed. Do not extend through carpet.
3. Use slotted-head screw to identify electrical power; use Phillips-head screw to identify conventional communications.
4. Use another distinctive screw head to identify third system, such as special-purpose wiring.

N. Protect underfloor raceway system from damage. Do not use the installed duct system as working platforms or walkways. Do not allow equipment or heavy traffic over duct during construction period, without first installing ramps over the duct. Ramps shall be designed so that imposed loads are not transferred to the duct. Components of the system that are damaged during construction shall be replaced.

O. Install concrete surrounding underfloor raceways according to Section 033000 "Cast-in-Place Concrete."

P. Afterset Inserts: Cut, hole saw, and drill slab and raceways to allow for installation at locations indicated on plans.

Q. Wiring shall comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and NFPA 70 requirements for wet locations.

1. Install wiring from outlet insert toward junction boxes, then to termination at panel.
2. Splices: All splices and taps shall be made in junction boxes. No splices or taps shall be made in raceways or outlet inserts.

3.3 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. Perform visual inspection of interior of each junction box to verify absence of dirt, dust, construction debris, and moisture. Replace damaged and malfunctioning components.
2. Prior to and after concrete pour, perform point-to-point tests of ground continuity and resistance of ground path between the most remote accessible fitting on each branch of each underfloor raceway system and the main electrical distribution grounding system.

    a. Determine cause and perform correction of any point-to-point resistance value that exceeds 0.05 ohms.
    b. Comply with NETA Acceptance Testing Specification about safety, suitability of test equipment, test instrument calibration, and test report and records.

D. Prepare test and inspection reports.

3.4 CLEANING

A. Clean and swab out underfloor raceways, inserts, and junction boxes after finish has been applied to floor slab, and remove foreign material, dirt, and moisture. Leave interiors clean and dry.

END OF SECTION 260539

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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Direct-buried conduit, ducts, and duct accessories.
2. Concrete-encased conduit, ducts, and duct accessories.
3. Handholes and boxes.
4. Manholes.

1.3 DEFINITIONS

A. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include duct-bank materials, including separators and miscellaneous components.
2. Include ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Include accessories for manholes, handholes, boxes, and other utility structures.
4. Include warning tape.
5. Include warning planks.

B. Shop Drawings:

1. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:

a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
b. Include duct entry provisions, including locations and duct sizes.
c. Include cover design.
d. Include grounding details.
e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.5 INFORMATIONAL SUBMITTALS

A. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.

1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
2. Drawings shall be signed and sealed by a qualified professional engineer.

B. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.

C. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.

D. Source quality-control reports.

E. Field quality-control reports.

1.6 MAINTENANCE MATERIALS SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Furnish cable-support stanchions, arms, insulators, and associated fasteners in quantities equal to 5 percent of quantity of each item installed.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

1.8 FIELD CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Construction Manager no fewer than thirty days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Owner's written permission.

B. Ground Water: Assume ground-water level is at grade level unless a lower water table is noted on Drawings.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR DUCTS AND RACEWAYS

A. Comply with ANSI C2.

2.2 CONDUIT

A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.

B. RNC: NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.3 NONMETALLIC DUCTS AND DUCT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Beck Manufacturing.
2. CANTEX INC.
3. IPEX USA LLC.
4. Manhattan/CDT.
5. Spiraduct/AFC Cable Systems, Inc.

B. Underground Plastic Utilities Duct: NEMA TC 2, UL 651, ASTM F 512, Type EPC-40, with matching fittings complying with NEMA TC 3 by same manufacturer as the duct.

C. Solvents and Adhesives: As recommended by conduit manufacturer.

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.
2. Warning Tape: Underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."
3. Concrete Warning Planks: Nominal 12 by 24 by 3 inches (300 by 600 by 75 mm) in size, manufactured from 6000-psi (41-MPa) concrete.

    a. Color: Red dye added to concrete during batching.
    b. Mark each plank with "ELECTRIC" in 2-inch- (50-mm-) high, 3/8-inch- (10-mm-) deep letters.

2.4 PRECAST CONCRETE HANDHOLES AND BOXES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Oldcastle Precast, Inc.
2. Utility Concrete Products, LLC.
3. Utility Vault Co.
4. Wausau Tile Inc.

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 steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.

2. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
3. Cover Legend: Molded lettering, "ELECTRIC" unless indicated in the drawings.
4. Configuration: Units shall be designed for flush burial and have integral closed bottom unless otherwise indicated.
5. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.

   a. Extension shall provide increased depth of 12 inches (300 mm) or as needed.
   b. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.

6. 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.
7. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks, plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.

   a. Windows shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
   b. Window opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
   c. Window openings shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.

8. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.5 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. General Requirements for Handholes and Boxes: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.

1. Color: Gray.
2. Configuration: Units shall be designed for flush burial and have 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" Or as indicated in the drawing.
6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
7. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

B. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Armorcast Products Company.
b. Carson Industries LLC.
c. NewBasis.
d. Quazite: Hubbell Power Systems, Inc.

2.6 PRECAST MANHOLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Rinker Group, Ltd.
2. Utility Concrete Products, LLC.
3. Utility Vault Co.
4. Wausau Tile Inc.

B. Comply with ASTM C 858.

C. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.

D. Precast Manholes: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.

E. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks, plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.

1. Windows shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.

2. Window opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
3. Window openings shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.

F. Concrete Knockout Panels: 1-1/2 to 2 inches (38 to 50 mm) thick, for future conduit entrance and sleeve for ground rod.

G. Ground Rod Sleeve: Provide a 3-inch (75-mm) PVC conduit sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the ducts routed from the facility.

H. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.7 CAST-IN-PLACE MANHOLES

A. Description: Underground utility structures, constructed in place, complete with accessories, hardware, and features. Include concrete knockout panels for conduit entrance and sleeve for ground rod.

B. Materials: Comply with ASTM C 858 and with Section 033000 "Cast-in-Place Concrete."

C. Structural Design Loading: As specified in "Underground Enclosure Application" Article.

2.8 UTILITY STRUCTURE ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bilco Company (The).
2. Quazite: Hubbell Power Systems, Inc.
3. Rinker Group, Ltd.
4. Utility Concrete Products, LLC.
5. Utility Vault Co.
6. Wausau Tile Inc.

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 with milled cover-to-frame bearing surfaces; diameter, 29 inches (725 mm).

a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.

2. Cover Legend: Cast in. Selected to suit system.

a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
b. Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.

3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.

a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. (60 L) where packaged mix complying with ASTM C 387, Type M, may be used.

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- (50-mm-) diameter eye, and 1-by-4-inch (25-by-100-mm) bolt.

1. Working Load Embedded in 6-Inch (150-mm), 4000-psi (27.6-MPa) Concrete: 13,000-lbf (58-kN) minimum tension.

E. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch- (31-mm-) diameter eye, rated 2500-lbf (11-kN) minimum tension.

F. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch- (22-mm-) 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 (180-kN) shear and 60,000-lbf (270-kN) 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 (13-mm) ID by 2-3/4 inches (69 mm) deep, flared to 1-1/4 inches (31 mm) minimum at base.

1. Tested Ultimate Pullout Strength: 12,000 lbf (53 kN) minimum.

H. Ground Rod Sleeve: 3-inch (75-mm), PVC conduit sleeve in manhole floors 2 inches (50 mm) 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 (13-mm) bolt, 5300-lbf (24-kN) rated pullout strength, and minimum 6800-lbf (30-kN) rated shear strength.

J. Cable Rack Assembly: Steel, hot-dip galvanized, except insulators.

1. Stanchions: T-section or channel; 2-1/4-inch (56-mm) nominal size; punched with 14 holes on 1-1/2-inch (38-mm) centers for cable-arm attachment.
2. Arms: 1-1/2 inches (38 mm) wide, lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 18 inches (450 mm) with 250-lb (114-kg) minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
3. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.

K. 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 (2 deg C). Capable of withstanding temperature of 300 deg F (150 deg C) 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.

L. Fixed Manhole Ladders: Arranged for attachment to roof or wall and floor of manhole. Ladder and mounting brackets and braces shall be fabricated from hot-dip galvanized steel.

M. Cover Hooks: Heavy duty, designed for lifts 60 lbf (270 N) and greater. Two required.

2.9 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.

C. Clear and grub vegetation to be removed, and protect vegetation to remain according to Section 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 Branch Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank unless otherwise indicated.

D. Underground Ducts Crossing Paved Paths, Walks and Driveways: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.
   1. Use trenchless technology involving horizontal jacking or directional boring as an alternative.

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-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 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 or Polymer concrete units, SCTE 77, Tier 8 structural load rating.
   4. Units Subject to Light-Duty Pedestrian Traffic Only: Polymer concrete units, SCTE 77, Tier 8 structurally tested according to SCTE 77 with 3000-lbf (13 345-N) vertical loading.
   5. Cover design load shall not exceed the design load of the handhole or box.

B. Manholes: Precast 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. Comply with Section 329200 "Turf and Grasses" and Section 329300 "Plants."

D. Cut and patch existing pavement in the path of underground ducts and utility structures according to the "Cutting and Patching" Article in Section 017300 "Execution."

3.5 DUCT INSTALLATION

A. Install ducts according to NEMA TCB 2.

B. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes, to drain in both directions.

C. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches (1200 mm), both horizontally and vertically, at other locations unless otherwise indicated.

D. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.

E. Installation Adjacent to High-Temperature Steam Lines: Where duct banks are installed parallel to underground steam lines, perform calculations showing the duct bank will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct bank crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.

F. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches (250 mm) o.c. for 5-inch (125-mm) ducts, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to end-bell spacing 10 feet (3 m) 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 (19 mm).
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 (3 m) 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 (1.03-MPa) hydrostatic pressure.

I. Pulling Cord: Install 100-lbf- (445-N-) 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 (150 mm) in nominal diameter.
2. Width: Excavate trench 12 inches (300 mm) wider than duct bank on each side.
3. Depth: Install top of duct bank at least 24 inches (600 mm) below finished grade in areas not subject to deliberate traffic, and at least 30 inches (750 mm) below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
4. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
5. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than four spacers per 20 feet (6 m) of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches (150 mm) 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.
6. Minimum Space between Ducts: 3 inches (75 mm) between ducts and exterior envelope wall, 3 inches (75 mm) between ducts for like services, and 4 inches (100 mm) between power and signal ducts.
7. 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 (75 mm) of concrete.
    b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of base. Install insulated grounding bushings on terminations at equipment.

8. 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.
9. 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.
10. Concrete Cover: Install a minimum of 3 inches (75 mm) of concrete cover at top and bottom, and a minimum of 2 inches (50 mm) on each side of duct bank.
11. 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 (15-mm) reinforcing-rod dowels extending a minimum of 18 inches (450 mm) into concrete on both sides of joint near corners of envelope.

12. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 033000 "Cast-in-Place Concrete." Place concrete carefully during pours to

prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.

K. Direct-Buried Duct Banks:

1. Excavate trench bottom to provide firm and uniform support for duct bank. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches (150 mm) in nominal diameter.
2. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
3. Space separators close enough to prevent sagging and deforming of ducts, with not less than four spacers per 20 feet (6 m) 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 (150 mm) between tiers.
4. Depth: Install top of duct bank at least 36 inches (900 mm) below finished grade unless otherwise indicated.
5. Set elevation of bottom of duct bank below frost line.
6. Install ducts with a minimum of 3 inches (75 mm) between ducts for like services and 6 inches (150 mm) between power and signal ducts.
7. Elbows: Install manufactured duct elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
8. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
    b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

9. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches (100 mm) 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 (75 mm) of sand as a bed for duct bank. Place sand to a minimum of 6 inches (150 mm) above top level of duct bank.
    b. Place minimum 6 inches (150 mm) of engineered fill above concrete encasement of duct bank.

L. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried ducts and duct banks, placing them 24 inches (600 mm) o.c. Align planks along the width and

along the centerline of duct bank. Provide an additional plank for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional planks 12 inches (300 mm) apart, horizontally.

M. Warning Tape: Bury warning tape approximately 12 inches (300 mm) above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches (75 mm) of centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) 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 (38 to 50 mm) thick, arranged as indicated.
3. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for cast-in-place concrete, formwork, and reinforcement.

B. Precast Concrete Handhole and Manhole Installation:

1. Comply with ASTM C 891 unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch (25-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevations:

1. Manhole Roof: Install with rooftop at least 15 inches (375 mm) below finished grade.
2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch (25 mm) above finished grade.
3. Install handholes with bottom below frost line, if applies in specific project location.
4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch (25 mm) 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. Dampproofing materials and installation are specified in Section 071113 "Bituminous Dampproofing." After ducts are connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.

H. Hardware: Install removable hardware, including pulling eyes, cable stanchions, 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 (97 mm) for manholes and 2 inches (50 mm) for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.7 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.

D. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.

E. Field cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

F. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.

1. Concrete: 3000 psi (20 kPa), 28-day strength, complying with Section 033000 "Cast-in-Place Concrete," with a troweled finish.
2. Dimensions: 10 inches wide by 12 inches deep (250 mm wide by 300 mm 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- (150-mm-) 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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

F. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Advance Products & Systems, Inc.
b. CALPICO, Inc.
c. Pipeline Seal and Insulator, Inc.
d. Proco Products, Inc.

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: Stainless steel.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. HOLDRITE.

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

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

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.

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.

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 (25-mm) 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 (25-mm) 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 260548.16 - 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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Restraint channel bracings.
2. Restraint cables.
3. Seismic-restraint accessories.
4. Mechanical anchor bolts.
5. Adhesive anchor bolts.

B. Related Requirements:

1. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. 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 agency acceptable to authorities having jurisdiction.
    b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For each seismic-restraint device.

1. Include design calculations and details for selecting seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. 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.

3. 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 agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. 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 nationally recognized testing laboratory 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 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: 115mph.
2. Building Classification Category: III.
3. Minimum 10 lb/sq. ft. (48.8 kg/sq. m) multiplied by maximum area of HVAC component projected on vertical plane normal to wind direction and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: D.
2. Assigned Seismic Use Group or Building Category as Defined in the CBC: III.

    a. Component Importance Factor: 1.0.
    b. Component Response Modification Factor: 2.5.
    c. Component Amplification Factor: 1.0 for units supported above center of gravity.
    d. Component Amplification Factor: 2.5 for units supported below center of gravity.

3. Design Spectral Response Acceleration at Short Periods (0.2 Second): 1.0%.
4. Design Spectral Response Acceleration at 1.0-Second Period: 0.6%.

2.2 RESTRAINT CHANNEL BRACINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. B-line, an Eaton business.
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Unistrut; Part of Atkore International.

B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end, with other matching components, and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.3 RESTRAINT CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Kinetics Noise Control, Inc.
2. Loos & Co., Inc.
3. Vibration Mountings & Controls, Inc.

B. Restraint Cables: ASTM A 492 stainless-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.4 SEISMIC-RESTRAINT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. B-line, an Eaton business.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.
4. TOLCO; a brand of NIBCO INC.

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

E. 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 used.

F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.5 MECHANICAL ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. B-line, an Eaton business.
2. Hilti, Inc.
3. Kinetics Noise Control, Inc.
4. Mason Industries, Inc.

B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in 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.

2.6 ADHESIVE ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Hilti, Inc.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.

B. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC 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.

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 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 specified in Section 033000 "Cast-in-Place Concrete."

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 (3.2 mm).
2. Install seismic-restraint devices using methods approved by 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 with the assistance of a factory-authorized service representative:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.

2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.

C. Seismic controls will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 260548.16

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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels, including arc-flash warning labels.
8. Miscellaneous identification products.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

D. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

B. Raceways and Cables Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.
2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

C. Warning labels and signs 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 (915 MM)."
3. Arc flash Warning in compliance with NEC 110.16: "WARNING – ARC FLASH HAZARD – APPROPRIATE PPE REQUIRED – FAILURE TO COMPLY CAN RESULT IN DEATH OR INJURY - REFER TO NFPA 70E".

2.3 LABELS

A. Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. LEM Products Inc.
c. Marking Services, Inc.
d. Panduit Corp.

B. Snap-Around Labels for Raceways and Cables Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceways they identify, and that stay in place by gripping action.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Marking Services, Inc.
c. Panduit Corp.
d. Seton Identification Products.

C. Self-Adhesive Labels:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Brother International Corporation.
c. LEM Products Inc.
d. Marking Services, Inc.
e. Panduit Corp.
f. Seton Identification Products.

2. Preprinted, 3-mil- (0.08-mm-) thick, vinyl flexible label with acrylic pressure-sensitive adhesive.

a. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized to fit the raceway diameter, such that the clear shield overlaps the entire printed legend.

3. Vinyl, thermal, transfer-printed, 3-mil- (0.08-mm-) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

a. Nominal Size: 3.5-by-5-inch (76-by-127-mm).

4. Marker for Tags: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

2.4 BANDS AND TUBES:

A. Snap-Around, Color-Coding Bands for Raceways and Cables: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameters sized to suit diameters of raceways or cables they identify, and that stay in place by gripping action.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Marking Services, Inc.

c. Panduit Corp.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameters of and shrunk to fit firmly around cables they identify. Full shrink recovery occurs at a maximum of 200 deg F (93 deg C). Comply with UL 224.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Panduit Corp.

2.5 TAPES AND STENCILS:

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Carlton Industries, LP.
b. Marking Services, Inc.
c. Panduit Corp.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide; compounded for outdoor use.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Carlton Industries, LP.
c. Marking Services, Inc.

C. Tape and Stencil for Raceways Carrying Circuits 600 V or Less: 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers placed diagonally over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stop stripes at legends.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. LEM Products Inc.
b. Marking Services, Inc.
c. Seton Identification Products.

D. Floor Marking Tape: 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Carlton Industries, LP.
    b. Seton Identification Products.

E. Underground-Line Warning Tape

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Brady Corporation.
    b. LEM Products Inc.
    c. Marking Services, Inc.
    d. Seton Identification Products.

2. Tape:

    a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical utility lines.
    b. Printing on tape shall be permanent and shall not be damaged by burial operations.
    c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

3. Color and Printing:

    a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
    b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
    c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".

4. Tag for system 600V or less:

    a. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
    b. Width: 3 inches (75 mm).
    c. Overall Thickness: 5 mils (0.125 mm).
    d. Foil Core Thickness: 0.35 mil (0.00889 mm).
    e. Weight: 28 lb/1000 sq. ft. (13.7 kg/100 sq. m).
    f. Tensile according to ASTM D 882: 70 lbf (311.3 N) and 4600 psi (31.7 MPa).

5. Tag for system above 600V:

    a. Reinforced, detectable three-layer laminate, consisting of a printed pigmented woven scrim, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright-colored, continuous-

printed on one side with the inscription of the utility, compounded for direct-burial service.

b. Width: 3 inches (75-mm).
c. Overall Thickness: 8 mils (0.2 mm).
d. Foil Core Thickness: 0.35 mil (0.00889 mm).
e. Weight: 34 lb/1000 sq. ft. (16.6 kg/100 sq. m).
f. Tensile according to ASTM D 882: 300 lbf (1334 N) and 12,500 psi (86.1 MPa).

F. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch (25 mm).

2.6 Tags

A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Carlton Industries, LP.
c. Marking Services, Inc.
d. Seton Identification Products.

B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.023 inch (0.58 mm) thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Carlton Industries, LP.
c. LEM Products Inc.
d. Panduit Corp.
e. Seton Identification Products.

C. Write-On Tags:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Carlton Industries, LP.
b. LEM Products Inc.
c. Seton Identification Products.

2. Polyester Tags: 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to raceway, conductor, or cable.
3. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 Signs

A. Metal-Backed Butyrate Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch (1-mm) galvanized-steel backing and with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal Size: 10 by 14 inches (250 by 360 mm).

4. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Champion America.
c. emedco.
d. Marking Services, Inc.

B. Laminated Acrylic or Melamine Plastic Signs:

1. Engraved legend.
2. Thickness:

a. For signs up to 20 sq. inches (129 sq. cm), minimum 1/16-inch- (1.6-mm-).
b. For signs larger than 20 sq. inches (129 sq. cm), 1/8 inch (3.2 mm) thick.
c. Engraved legend with black letters on white face.
d. Punched or drilled for mechanical fasteners.
e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

3. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Carlton Industries, LP.
c. emedco.
d. Marking Services, Inc.

2.8 CABLE TIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ideal Industries, Inc.
2. Marking Services, Inc.
3. Panduit Corp.

B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C) according to ASTM D 638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black, except where used for color-coding.

C. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C) according to ASTM D 638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black.

D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, self-locking.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C) according to ASTM D 638: 7000 psi (48.2 MPa).
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
5. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

G. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

H. 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.

I. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

J. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

K. 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 (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

L. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.

3.3 IDENTIFICATION SCHEDULE

A. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high black letters on 20-inch (500-mm) centers. Stop stripes at legends. Apply stripes to the following finished surfaces:

1. Floor surface directly above conduits running beneath and within 12 inches (300 mm) 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: Snap-around labels. Install labels at 30-foot (10-m) maximum intervals.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive vinyl label. Install labels at 30-foot (10-m) maximum intervals.

D. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. "EMERGENCY POWER."
2. "POWER."
3. "UPS."

E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder and branch-circuit conductors.

a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.
b. Colors for 208/120-V Circuits:

1) Phase A: Black.
2) Phase B: Red.
3) Phase C: Blue.

c. Colors for 480/277-V Circuits:

1) Phase A: Brown.
2) Phase B: Orange.
3) Phase C: Yellow.

d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) 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.

F. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation.

G. Install instructional sign, including the color code for grounded and ungrounded conductors using adhesive-film-type labels.

H. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive vinyl labels with the conductor or cable designation, origin, and destination.

I. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive vinyl labels with the conductor designation.

J. Conductors To Be Extended in the Future: Attach marker tape to conductors and list source.

K. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker-tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

L. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.
1. Install underground-line warning tape for direct-buried cables and cables in raceways.

M. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

N. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.

1. Comply with 29 CFR 1910.145.
2. Identify system voltage with black letters on an orange background.
3. Apply to exterior of door, cover, or other access.
4. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:

a. Power-transfer switches.
b. Controls with external control power connections.

O. Arc Flash Warning Labeling: Self-adhesive thermal transfer vinyl labels.

1. Comply with NFPA 70E and ANSI Z535.4.

P. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

Q. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer.

R. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and 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 unless equipment is provided with its own identification.

1. Labeling Instructions:

   a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine plastic label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
   b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
   c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
   d. Unless labels are provided with self-adhesive means of attachment, fasten them 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 in the form of a self-adhesive, 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. Substations.
   h. Emergency system boxes and enclosures.
   i. Enclosed switches.
   j. Enclosed circuit breakers.
   k. Enclosed controllers.
   l. Push-button stations.
   m. Power-transfer equipment.
   n. Contactors.
   o. Remote-controlled switches, dimmer modules, and control devices.
   p. Battery racks.
   q. Power-generating units.
   r. Monitoring and control equipment.
   s. UPS equipment.
   t. ATS
   u. PV Inverter

END OF SECTION 260553

SECTION 260572 - OVERCURRENT PROTECTIVE DEVICE SHORT-CIRCUIT STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

1.3 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.

1. Short-circuit study input data, including completed computer program input data sheets.
2. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.

    a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary

submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

b. Revised single-line diagram, reflecting field investigation results and results of short-circuit study.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Short-Circuit Study Specialist.

B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.6 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Short-Circuit Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Short-Circuit Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. SKM Systems Analysis, Inc.

B. Comply with IEEE 399 and IEEE 551.

C. Analytical features of fault-current-study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Comments and recommendations for system improvements, where needed.

E. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

F. Short-Circuit Study Input Data: As described in "Power System Data" Article in the Evaluations.

G. Short-Circuit Study Output:

1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. Equivalent impedance.

2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. Calculated asymmetrical fault currents:

1) Based on fault-point X/R ratio.
2) Based on calculated symmetrical value multiplied by 1.6.
3) Based on calculated symmetrical value multiplied by 2.7.

3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. No AC Decrement (NACD) ratio.
e. Equivalent impedance.
f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Obtain all data necessary for the conduct of the study.

1. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of Architect.
2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. For equipment that is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.

B. Gather and tabulate the following input data to support the short-circuit study. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.

4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
8. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
9. Motor horsepower and NEMA MG 1 code letter designation.
10. Cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.2 SHORT-CIRCUIT STUDY

A. Perform study following the general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:

1. Electric utility's supply termination point.
2. Incoming switchgear.
3. Unit substation primary and secondary terminals.
4. Low-voltage switchgear.
5. Motor-control centers.
6. Control panels.

7. Standby generators and automatic transfer switches.
8. Branch circuit panelboards.
9. Disconnect switches / Enclosed Circuit breakers

3.3 ADJUSTING

A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.

B. Contractor shall verify AIC rating of all of the electrical equipment based on this study and shall purchase the equipment and devices with appropriate rating. Modifications to the AIC rating of the equipment shall be without additional cost to the client.

3.4 DEMONSTRATION

A. Train Owner's operating and maintenance personnel in the use of study results.

END OF SECTION 260572

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Standalone daylight-harvesting switching and dimming controls.
2. Indoor occupancy and vacancy sensors.
3. Switchbox-mounted occupancy sensors.
4. Digital timer light switches.
5. High-bay occupancy sensors.
6. Outdoor motion sensors.
7. Lighting contactors.
8. Emergency shunt relays.

B. Related Requirements:

1. Section 262726 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Show installation details for the following:

a. Occupancy sensors.
b. Vacancy sensors.

2. Interconnection diagrams showing field-installed wiring.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and elevations, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which equipment will be attached.
3. Items penetrating finished ceiling, including the following:

    a. Luminaires.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Control modules.

B. Field quality-control reports.

C. Sample Warranty: For manufacturer's warranties.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of lighting control device to include in operation and maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On manufacturer's website. Provide names, versions, and website addresses for locations of installed software.
3. Device address list.
4. Printout of software application and graphic screens.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

    a. Faulty operation of lighting control software.
    b. Faulty operation of lighting control devices.

2. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 DAYLIGHT-HARVESTING DIMMING CONTROLS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Cooper Industries, Inc.

2. Hubbell Building Automation, Inc.
3. Leviton Manufacturing Co., Inc.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. Watt Stopper.

B. System Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.

1. Lighting control set point is based on two lighting conditions:

a. When no daylight is present (target level).
b. When significant daylight is present.

2. System programming is done with two hand-held, remote-control tools.

a. Initial setup tool.
b. Tool for occupants to adjust the target levels by increasing the set point up to 25 percent, or by minimizing the electric lighting level.

C. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with integrated separate power pack, to detect changes in indoor lighting levels that are perceived by the eye.

D. Electrical Components, Devices, and Accessories:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Sensor Output: 0- to 10-V dc to operate luminaires. Sensor is powered by controller unit.
3. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc (120 to 640 lux).

E. Power Pack: Digital controller capable of accepting 4 RJ45 inputs with two outputs rated for 13-A ballast load or LED at 120- and 277-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc Class 2 power source, as defined by NFPA 70.

1. With integral current monitoring

a. Compatible with digital addressable lighting interface.

1) Plenum rated.

2.2 INDOOR OCCUPANCYAND VACANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper Industries, Inc.
2. Hubbell Building Automation, Inc.
3. Leviton Manufacturing Co., Inc.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. Lutron Electronics Co., Inc.
6. Sensor Switch, Inc.

7. Watt Stopper.

B. General Requirements for Sensors:

1. Ceiling-mounted, solid-state indoor occupancy and vacancy sensors.
2. Dual technology.
3. Separate power pack.
4. Hardwired connection to switch; and BAS and lighting control system.
5. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
6. Operation:
   a. Combination Sensor: Unless otherwise indicated, sensor shall be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
7. Sensor Output: Sensor is powered from the power pack.
8. Power: Line voltage.
9. Power Pack: Dry contacts rated for 20-A ballast or LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
10. Mounting:
    a. Sensor: Suitable for mounting in any position on a standard outlet box.
    b. Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
    c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
12. Bypass Switch: Override the "on" function in case of sensor failure.
13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lux); turn lights off when selected lighting level is present.

C. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.

2.3 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper Industries, Inc.
2. Hubbell Building Automation, Inc.
3. Leviton Manufacturing Co., Inc.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. Lutron Electronics Co., Inc.
6. Sensor Switch, Inc.
7. Watt Stopper.

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox, with provisions for connection to BAS.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application, and shall comply with California Title 24.
2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (0 to 49 deg C).
4. Switch Rating: Not less than 800-VA ballast or LED load at 120 V, 1200-VA ballast or LED load at 277 V, and 800-W incandescent.

C. Wall-Switch Sensor:

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft. (84 sq. m).
2. Sensing Technology: Dual technology - PIR and ultrasonic.
3. Switch Type: SP, field-selectable automatic "on," or manual "on," automatic "off."
4. Capable of controlling load in three-way application.
5. Voltage: Dual voltage - 120 and 277 V.
6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc (108 to 1600 lux). The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
8. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
9. Color: White.
10. Faceplate: Color matched to switch.

2.4 HIGH-BAY OCCUPANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Hubbell Building Automation, Inc.

B. General Description: Solid-state unit. The unit is designed to operate with the lamp and ballasts indicated.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Operation: Turn lights on when coverage area is occupied, and to half-power when unoccupied; with a time delay for turning lights to half-power that is adjustable over a minimum range of 1 to 16 minutes.
3. Continuous Lamp Monitoring: When lamps are dimmed continuously for 24 hours, automatically turn lamps on to full power for 15 minutes for every 24 hours of continuous dimming.
4. Power: Line voltage.
5. Operating Ambient Conditions: 32 to 149 deg F (0 to 65 deg C).
6. Mounting: Threaded pipe.
7. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
8. Detector Technology: PIR.
9. Power and dimming control from the luminaire ballast that has been modified to include the dimming capacitor.

C. Detector Coverage: User selectable by interchangeable PIR lenses, suitable for mounting heights from 12 to 50 feet (3.7 to 15.2 m).

D. Accessories: Obtain manufacturer's installation and maintenance kit with laser alignment tool for sensor positioning and power port connectors.

2.5 OUTDOOR MOTION SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper Industries, Inc.
2. Hubbell Building Automation, Inc.
3. Leviton Manufacturing Co., Inc.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. Sensor Switch, Inc.
6. Watt Stopper.

B. General Requirements for Sensors: Solid-state outdoor motion sensors.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application, and shall comply with California Title 24.
2. Dual-technology (PIR and infrared) type, weatherproof. Detect occurrences of 6-inch-(150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm). Comply with UL 773A.
3. Switch Rating:

   a. Luminaire-Mounted Sensor: 1000-W incandescent, 500-VA fluorescent/LED.
   b. Separately Mounted Sensor: Dry contacts rated for 20-A ballast or LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.

4. Switch Type: SP, field-selectable automatic "on," or manual "on," automatic "off." With bypass switch to override the "on" function in case of sensor failure.
5. Voltage: Dual voltage, 120- and 277-V type.
6. Detector Coverage:

    a. Standard Range: 210-degree field of view, with a minimum coverage area of 900 sq. ft. (84 sq. m).
    b. Long Range: 180-degree field of view and 110-foot (34-m) detection range.

7. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc (108 to 1600 lux). The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
8. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
9. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and help eliminate false "off" switching.
10. Operating Ambient Conditions: Suitable for operation in ambient temperatures ranging from minus 40 to plus 130 deg F (minus 40 to plus 54 deg C), rated as "raintight" according to UL 773A.

2.6 EMERGENCY SHUNT RELAY

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Lighting Control and Design.
2. Watt Stopper.

B. Description: NC, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.

1. Coil Rating: 277 V.

2.7 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.

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

3.2 SENSOR INSTALLATION

A. Comply with NECA 1.

B. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

C. Install and aim sensors in locations to achieve not less than 90-percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.3 CONTACTOR INSTALLATION

A. Comply with NECA 1.

B. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.4 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch (13 mm).

C. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.5 IDENTIFICATION

A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate lighting control devices and 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. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Lighting control devices will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.8 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.9 DEMONSTRATION

A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control systems specified in Section 260943.16 "Addressable-Luminaire Lighting Controls".

B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 260923

SECTION 260943.16 - ADDRESSABLE-LUMINAIRE LIGHTING CONTROLS

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 lighting controls for addressable luminaires, based on DALI digital controls.

1.3 DEFINITIONS

A. BAS: Building automation system.

B. DALI: Digital addressable lighting interface.

C. Data Bus: Two wires used to communicate with bus connected devices.

D. DDC: Direct digital control.

E. Device: A collective term for DALI-compliant bus connected devices, including fluorescent ballasts, incandescent luminaires, manual switches, switching relays, and similar. Sometimes also called "slave unit."

F. Group: A set of devices that respond at the same time to messages on the data bus.

G. IP: Internet protocol.

H. IR: Infrared.

I. LAN: Local area network.

J. 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.

K. Scene: Digital light level associated with a preset; stored in the luminaire ballast.

L. TCP/IP: Transmission control protocol/Internet protocol.

M. VPN: Virtual private network.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for control modules, power distribution components, relays, manual switches and plates, and conductors and cables.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Sound data including results of operational tests of central dimming controls.
4. Operational documentation for software and firmware.

B. Shop Drawings:

1. Floor Plans: Location, orientation, and coverage area of each sensor; group designations; and other specific design symbols and designations as required to define the installation, location, and configuration of all control devices.
2. Address Drawing: Reflected ceiling plan and floor plans, showing data-bus-connected devices, address for each device, and device groups. The plans shall be based on construction plans, using the same legend, symbols, and schedules.
3. Point List and Data Bus Load: Summary list of all control devices, sensors, ballasts, and other loads connected to each data bus and total connected load for each data bus. Include percentage of rated connected load and device addresses.
4. Wire Termination Diagrams and Schedules: Coordinate nomenclature and presentation with Drawings and block diagram. Differentiate between manufacturer-installed and field-installed wiring.
5. 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 used. Describe characteristics of network and other data communication lines.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

1. Show interconnecting signal and control wiring, and interface devices that show compatibility of inputs and outputs.
2. For control interfaces and adapters, list network protocols and provide statements from manufacturers that input and output devices comply with interoperability requirements of the protocol.

B. Field quality-control reports.

C. Sample Warranty: For manufacturer's special warranty.

D. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For lighting controls to include in emergency, operation, and maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: Username and password for manufacturer's support website.
3. Device address list.
4. Printout of software application and graphic screens.
5. Adjustments of scene preset controls, adjustable fade rates, and fade overrides.
6. Operation of adjustable zone controls.
7. Testing and adjusting of panic and emergency power features.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Bus Power Supplies: Equal to two percent of amount installed, but no fewer than two.
2. Controller/Gateways: Equal to two percent of amount installed, but no fewer than two.
3. Incandescent Switching and Dimming Modules: Equal to two percent of amount installed, but no fewer than two.
4. Fluorescent Ballasts: Equal to two percent of amount installed, but no fewer than two.
5. Lighting Control Relays: Equal to two percent of amount installed, but no fewer than two.

1.8 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Software: Failure of input and output to execute switching or dimming commands.
b. Failure of modular relays to operate under manual or software commands.
c. Ballast failure.
d. Damage of electronic components due to transient voltage surges.

2. Warranty Periods:

a. For DALI Ballasts: Three years from date of Substantial Completion.
b. For Control Components That Are Not Part of Ballasts: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. DALI:

1. Components: Individually addressable devices (such as ballasts, relays, dimmers, and switches) that are operated from digital signals received through a DALI-compliant bus, from data-entry and -retrieval devices (such as computers, Internet portals, hand-held IR programming devices, wired Ethernet hubs, wireless IEEE 802.11 hubs). Devices also report status to data-entry and -retrieval devices though the bus.
2. Digital Control: Use peer-to-peer communication and distributed logic, where the failure of any single component shall be automatically isolated and not affect global system functions.

B. Ethernet LAN:

1. Provide an Ethernet LAN to connect controller/gateways to a PC running a Microsoft Windows operating system. Comply with requirements in Section 271500 "Communications Horizontal Cabling."
2. Ethernet Protocols: Comply with and be compatible with 10/100 BaseT TCP/IP routers and networks.
3. TCP/IP Modem: Capable of maintaining a secure Internet connection using VPN or equivalent protocol.

C. Interface with HVAC DDC System: Hardware and software shall interface with HVAC DDC system to monitor, control, display, and record data for use in processing reports. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

1. Hardwired Points:

a. Monitoring: On-off status.
b. Control: On-off operation.

2. Communication Interface: Comply with ASHRAE 135. Communication shall interface with HVAC DDC system to remotely control and monitor lighting from HVAC DDC system operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through DDC system for HVAC. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

D. Surge Protective Device: Factory installed as an integral part of control components or field-mounted surge protective device complying with UL 1449, SPD Type 2.

E. Operation: Input signal from digital signal sources switches or dims DALI devices associated with ballasts or luminaires, or switches field-deployed, DALI-compliant, control relays.

1. Each device and relay is connected to a digital data bus.
2. Each DALI device and relay has a digital address and can be operated by a digital signal.
3. Each device or relay can be assigned to any or all of 16 available groups connected to a single data bus.

4. Each dimming ballast may have as many as 16 preset lighting levels or scenes. Scenes can be programmed to ballasts and may be applied to groups.

F. 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.

G. Comply with 47 CFR 15, Subparts A and B, for Class A digital devices.

H. Comply with protocol described in IEC 60929, Annexes E and G, for DALI lighting control devices, wiring, and computer hardware and software.

I. Comply with UL 916.

2.2 BUS POWER SUPPLY

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Leviton Manufacturing Co., Inc.
2. Lightolier; a Philips group brand.
3. Starfield Controls, Inc.
4. Tridonic.

B. Description: Supply power to data bus for 64 addressable devices, suitable for use with NFPA 70, Class 2 control circuit.

1. Primary Power: Field selectable, 120 and 277 V.
2. Power Supply: Regulated to maintain the operating voltage above 15-V dc under full load, and rated for full charging load of 250 mA and a minimum maintained connected load of 190 mA.
3. Pilot Lights: Indicate data bus ground-fault and data bus traffic.

2.3 CONTROLLER/GATEWAYS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Leviton Manufacturing Co., Inc.
2. Lightolier; a Philips group brand.
3. Starfield Controls, Inc.
4. Tridonic.

B. Description: DALI controller/gateways link the distributed data buses with an Ethernet network to provide computer configuration, control, analysis, and maintenance. Controller/gateways operate independently and continue to process local inputs and schedules when disconnected from the LAN. Controller/gateways shall provide local intelligence and features including the following:

1. Integrated real-time clock with automatic daylight savings adjustment and leap-year correction.
2. Integrated sunrise/sunset support based on the site location (latitude and longitude).
3. Automatic time schedules, to control groups for scheduled occupancy with support for holiday exceptions.
4. Two digital outputs for additional control and interlocking with external equipment such as fans, valves, and security panels.
5. Support two data bus(es).
6. Computer Monitoring and Configuration: The controller/gateway shall allow configuration, monitoring, and analysis from PCs on the Ethernet LAN.

C. Each data bus shall have the capacity to control 64 addressable devices, using NFPA 70, Class 2 control circuit.

1. Each data bus shall have the capacity to control up to 16 groups and scenes.
2. 10 BaseT Ethernet port for DDC system for HVAC connection.
3. LED indicator lights for Ethernet status (link, send, and receive), power-on, and LAN failure.
4. Linking of switch and sensor inputs to relay and ballast outputs.
5. Viewing relay and ballast output status.
6. Controlling relay and ballast outputs.
7. Setting device addresses.
8. Assigning switch and sensor inputs and relay and ballast output modes.

D. Allow connection of the following DALI-compliant addressable devices:

1. Fluorescent luminaire switching and dimming, for linear and compact lamps.
2. Incandescent luminaire switching and dimming.
3. HID and HPS luminaire switching and dimming.
4. LED luminaire switching and dimming.
5. Occupancy and photoelectric sensors.
6. Emergency lighting interface complying with UL 924.

E. Stores system programming in nonvolatile memory.

1. Switch to enable or disable software programming.

2.4 USER INTERFACE

A. Workstations: A laptop PC, with Microsoft Windows operating system and lighting control system management software installed. With automatic backup.

1. Include documentation, storage media, and licensing for a minimum of five concurrent users.

B. Tablet Computer: Handheld, with custom graphical user-interface software, supplied by the controller/gateway supplier. The software shall provide for all DALI-protocol programming commands to be applied to the controller/gateway via a tethered connection.

C. Web Interface: Internet portal, with 10 unique username and password(s), and a custom graphical user interface, allowing DALI-protocol programming commands to be applied to the controller gateway via LAN.

D. IR Programming Assistant: Handheld, with custom graphical user-interface software, supplied by the controller/gateway supplier to program the manual switches.

2.5 LIGHTING CONTROL SYSTEM MANAGEMENT SOFTWARE

A. The software shall provide for programming, configuring, and monitoring all devices connected to all data buses of the lighting control system, using application-specific software with Microsoft Windows-based, user-friendly software with graphical user-interface designed screens.

1. The software shall be object oriented with pop-up menus and built-in help screens. All specified features of the data-bus-connected devices and those associated with controller/gateways shall be included in the software.

2.6 LUMINAIRE SWITCHING AND DIMMING MODULES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Leviton Manufacturing Co., Inc.
2. Lightolier; a Philips group brand.
3. Starfield Controls, Inc.

B. Description: Comply with DALI exponential dimming curve calibrated for the connected lamp type, group, and scene settings, and with DALI light-level and configuration commands. Dimmer rise time shall be not less than 15 microseconds.

2.7 SENSORS

A. Comply with requirements in Section 260923 "Lighting Control Devices." All sensors shall be DALI-protocol compliant.

B. Daylight Harvesting Switching and Dimming Controls:

1. Adjustments and Set Points: All adjustments with exception of sensor range shall be made via the communication network.
2. Remote Monitoring and Reporting: Sensor value shall be displayed when queried by lighting management software or shall automatically report based on a change of value or change of time period setting.

C. Indoor Occupancy Sensors: May be powered directly from the lighting control network or with a standalone power supply. Units powered with a standalone power supply shall interface with the lighting control system through an electrically isolated digital input.

2.8 RELAYS

A. Relays: Electrically operated, mechanically held single-pole switch, rated at 20 A at 277 V. Short-circuit current rating shall be not less than 5 kA. Pilot light indicates when relay is closed and latched. Control shall be by DALI digital data bus. Relay status shall be displayed when queried by lighting management software.

B. Relay Panel: A single enclosure with incoming lighting branch circuits, relays, and connection to the DALI digital control network.

1. Enclosure: NEMA 250, Type 1 unless otherwise indicated.
2. Barriers to separate low-voltage and line-voltage components.
3. Directory: Cover mounted, identifying each relay with its device address and naming the load controlled.

C. Individually Mounted Relays:

1. Enclosure: Standard outlet box or NEMA 250, Type 1 unless otherwise indicated.
2. Directory: Cover mounted, identifying each relay with its device address.

2.9 MANUAL SWITCHES AND PLATES

A. Connection Type: RS-485 protocol, Category 5e UTP cable, using RJ-45 connectors. Power shall be from the control unit.

B. Push-Button Switches: Modular, operating over the DALI digital data bus.

1. Each switch shall control the following functions, in coordination with programmed sequence of operation and related sensors:

a. On.
b. Off.
c. Dimming, increase light level.
d. Dimming, decrease light level.
e. Return to preset light level.

2. LED Pilot Lights: On to indicate that the control is active, or when the manual control is operated.
3. Match color and style specified in Section 262726 "Wiring Devices."
4. Integral IR receiver for programming.

C. Wall Plates: Single and multigang plates as specified in Section 262726 "Wiring Devices."

D. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.10 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Class 2 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Digital and Multiplexed Signal Cables: UTP cable with copper conductors, complying with TIA/EIA-568-B.2, Category 5e for horizontal copper cable and with Section 271500 "Communications Horizontal Cabling."

PART 3 - EXECUTION

3.1 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install cables in raceways and cable trays 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. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental airspaces, including plenum ceilings.
2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
3. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.2 IDENTIFICATION

A. Identify system components, wiring, cabling, boxes, cabinets, and terminals. Comply with identification requirements specified in Section 260553 "Identification for Electrical Systems."

B. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with Section 260553 "Identification for Electrical Systems."

C. Identify all ceiling-mounted controls with data bus number and device address.

D. Label each device cable within 6 inches (152 mm) of connection to bus power supply or termination block.

3.3 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

1. Test continuity of each circuit.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Test each bus controller using local and remote controls.
2. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. 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.

C. Field Test Reports:

1. Printed list of all points created from actual queries of all addressed control points to include lamps, ballasts, manual controls, and sensors.
2. Event log verifying the performance of all devices generating event messages to include occupancy sensors, control buttons, alarm messages, and any other change of value messages.

D. Lighting controls will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies bus controllers included and describes query results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.4 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.
2. Activate luminaires and verify that all lamps are operating at 100 percent.
3. Burn-in fluorescent lamps at 100 percent for 100 hours.
4. Confirm correct communications wiring, initiate communications between DALI devices and controller/gateways, and program the lighting control system according to approved configuration schedules, time-of-day schedules, and input override assignments.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from 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 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the control unit and operator interface.

END OF SECTION 260943.16

SECTION 261219 - PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

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 pad-mounted, liquid-filled, medium-voltage distribution transformers, with primary and secondary bushings within or without air-terminal enclosures.

1.3 DEFINITIONS

A. BIL: Basic Impulse Insulation Level.

B. Bushing: An insulating structure including a central conductor, or providing a central passage for a conductor, with provision for mounting on a barrier, conducting or otherwise, for the purpose of insulating the conductor from the barrier and conducting current from one side of the barrier to the other.

C. Bushing Elbow: An insulated device used to connect insulated conductors to separable insulated connectors on dead-front, pad-mounted transformers and to provide a fully insulated connection. This is also called an "elbow connector."

D. Bushing Insert: That component of a separable insulated connector that is inserted into a bushing well to complete a dead-front, load break or nonload break, separable insulated connector (bushing).

E. Bushing Well: A component of a separable insulated connector, either permanently welded or clamped to an enclosure wall or barrier, having a cavity that receives a replaceable component (bushing insert) to complete the separable insulated connector (bushing).

F. Elbow Connector: See "bushing elbow" above.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: For pad-mounted, liquid-filled, medium-voltage transformers.

1. Include plans and elevations showing major components and features.

    a. Include a plan view and cross section of equipment base, showing clearances, required workspace, and locations of penetrations for grounding and conduits.

2. Include details of equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include single-line diagram.
4. Include list of materials.
5. Include nameplate data.
6. Manufacturer's published time-current curves of the transformer high-voltage fuses, with transformer damage curve, inrush curve, and thru fault current indicated.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Utilities site plan, drawn to scale, showing heavy equipment or truck access paths for maintenance and replacement.

B. Qualification Data: For testing agency.

C. Seismic Qualification Certificates: For transformer assembly, 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.

D. Product Certificates: For transformers, signed by product manufacturer.

E. Source quality-control reports.

F. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 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 IEEE C2.

C. Comply with IEEE C57.12.00.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: The transformers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the transformer will remain in place without separation of any parts when subjected to the seismic forces specified and the transformer will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.
3. Component Amplification Factor: 2.5.
4. Component Response Modification Factor: 6.0.

B. Windings Material: Copper.

C. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, fully shielded, separable-elbow type, suitable for plugging into the inserts provided in the high-voltage section of the transformer. Connected in each phase of incoming circuit and ahead of any disconnecting device.

D. Winding Connections: The connection of windings and terminal markings shall comply with IEEE C57.12.70.

E. Efficiency: Comply with 10 CFR 431, Subpart K.

F. Insulation: Transformer kVA rating shall be as follows: The average winding temperature rise above a 30 deg C ambient temperature shall not exceed 65 deg C and 80 deg C hottest-spot temperature rise at rated kVA when tested according to IEEE C57.12.90, using combination of connections and taps that give the highest average winding temperature rise.

G. Tap Changer: External handle, for de-energized operation.

H. Tank: Sealed, with welded-on cover. Designed to withstand internal pressure of not less than 7 psi (50 kPa) without permanent distortion and 15 psig (104 kPa) without rupture. Comply with IEEE C57.12.36.

I. Enclosure Integrity: Comply with IEEE C57.12.28 for pad-mounted enclosures that contain energized electrical equipment in excess of 600 V that may be exposed to the public.

J. Mounting: An integral skid mounting frame, suitable to allow skidding or rolling of transformer in any direction, and with provision for anchoring frame to pad.

K. Insulating Liquids:

1. Mineral Oil: ASTM D 3487, Type II, and tested for compliance with ASTM D 117.
2. Less-Flammable Liquids:

a. Edible-Seed-Oil-Based Dielectric: Listed and labeled by an NRTL as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic, having passed the Organisation for Economic Co-operation and Development G.L.203 with zero mortality, and shall be certified by the U.S. Environmental Protection Agency as biodegradable, meeting Environmental Technology Verification requirements.
b. Biodegradable and Nontoxic Dielectric: Listed and labeled by an NRTL as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92.

L. Sound level shall comply with NEMA TR 1 requirements.

M. Corrosion Protection:
1. Base and Cabinets of Two Compartment Transformers: Fabricate from stainless steel according to ASTM A 167, Type 304 or 304L, not less than No. 13 U.S. gage. Coat transformer with manufacturer's standard green color coating complying with requirements of IEEE C57.12.28, in manufacturer's standard color green.

2.3 THREE-PHASE TRANSFORMERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB.
2. Cooper Industries, Inc.
3. Eaton.
4. General Electric Company.

B. Description:

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with IEEE C57.12.26.

C. Compartment Construction:
1. Double-Compartment Construction: Individual compartments for high- and low-voltage sections, formed by steel isolating barriers that extend full height and depth of compartments, with hinged, lift-off doors and three-point latching, with a stop in the open position and provision for padlocking.

D. Primary Fusing: Designed and rated to provide thermal protection of transformer by sensing overcurrent and high liquid temperature.

1. 150-kV BIL current-limiting fuses, conforming to requirements of IEEE C37.47.
2. Interrupting Rating: 50,000 rms A symmetrical at system voltage.
3. Fuse Assembly: Bayonet-type, liquid-immersed, expulsion fuses in series with liquid-immersed, partial-range, current-limiting fuses. Bayonet fuse shall sense both high currents and high oil temperature to provide thermal protection to the transformer.
4. Provide bayonet fuse assembly with an oil retention valve and an external drip shield inside the housing to eliminate or minimize oil spills. Valve shall close when fuse holder is removed and an external drip shield is installed.
5. Provide a conspicuously displayed warning adjacent to bayonet fuse(s), cautioning against removing or inserting fuses unless transformer has been de-energized and tank pressure has been released.

E. High-Voltage Section: Dead-front design.

1. To connect primary cable, use separable insulated connectors; coordinated with and complying with requirements of Section 260513 "Medium-Voltage Cables." Bushings shall be one-piece units, with ampere and BIL ratings the same as connectors.
2. Bushing inserts and feed-through inserts:

    a. Conform to the requirements of IEEE 386.
    b. Rated at 200 A, with voltage class matching connectors. Provide a parking stand near each bushing well. Parking stands shall be equipped with insulated standoff bushings for parking of energized load-break elbow connectors on parking stands.
    c. Provide insulated protective caps for insulating and sealing out moisture from unused bushing inserts and insulated standoff bushings.

3. Bushing wells configured for loop-feed application.
4. Access to liquid-immersed fuses.
5. Dead-front surge arresters.
6. Tap-changer operator.
7. Load-Break Switch:

    a. Radial-feed, liquid-immersed type with voltage class and BIL matching that of separable connectors, with a continuous current rating and load-break rating of 200 amperes, and a make-and-latch rating of 12 kA rms symmetrical.
    b. Loop-feed sectionalizing switches, using three two-position, liquid-immersed-type switches for closed transition loop-feed and sectionalizing operation. Voltage class and BIL shall match that of separable connectors, with a continuous current rating and load-break rating of 200 amperes, and a make-and-latch rating of 12 kA rms symmetrical. Switch operation shall be as follows:

        1) Position I: Line A connected to line B and both lines connected to the transformer.
        2) Position II: Transformer connected to line A only.
        3) Position III: Transformer connected to line B only.
        4) Position IV: Transformer disconnected and line A not connected to line B.
        5) Position V: Transformer disconnected and line A connected to line B.

8. Ground pad.

F. Low-Voltage Section:

1. Bushings with spade terminals drilled for terminating the number of conductors indicated on the Drawings, and the lugs that comply with requirements of Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
2. Metering: Coordinated with and complying with requirements of Section 262713 "Electricity Metering." Install the following:

   a. Sensors.
   b. BAS interface.
   c. Kilowatt-hour meter.
   d. Kilowatt-hour demand meter.

G. Capacities and Characteristics:

1. Power Rating (kVA): 2,000 KVA
2. Voltage Ratings: 12 KV - 480Y/277 V.
3. Taps: Comply with IEEE C57.12.26 requirements.
4. Transformer BIL (kV): Comply with IEEE C57.12.26 requirements.
5. Minimum Tested Impedance (Percent at 85 deg C): 4.03.
6. K-factor: K-13 complying with UL 1562.
7. Comply with FM Global Class No. 3990.
8. Comply with UL listing requirements for combination classification and listing for transformer and less-flammable insulating liquid.

H. Transformer Accessories:

1. Drain and filter connection.
2. Filling and top filter press connections.
3. Pressure-vacuum gauge.
4. Dial-type analog thermometer with alarm contacts.
5. Magnetic liquid level indicator with high and low alarm contacts.
6. Automatically resetting pressure-relief device. Device flow shall be as recommended by manufacturer. With alarm contacts and a manual bleeder.
7. Stainless-steel ground connection pads.
8. Machine-engraved nameplate, made of anodized aluminum or stainless steel.
9. Sudden pressure relay for remote alarm or trip when internal transformer pressure rises at field-set rate. Provide with seal-in delay.

2.4 SERVICE CONDITIONS

A. Transformers shall be suitable for operation under service conditions specified as usual service conditions in IEEE C57.12.00, except for the following:

1. Altitudes above 3300 feet (1000 m).
2. Cooling air temperature exceeds limits.
3. Excessive load current harmonic factor.
4. Operation above rated voltage or below rated frequency.

5. Exposure to explosive environments.
6. Exposure to fumes, vapors, or dust.
7. Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.
8. Exposure to seismic shock or to abnormal vibration, shock, or tilting.
9. Exposure to excessively high or low temperatures.
10. Unusual transportation or storage conditions.
11. Unusual grounding resistance conditions.

2.5 CONTROL NETWORK

A. Controllers: Support serial MS/TP and Ethernet IP communications, and able to communicate directly via RS-485 serial networks and Ethernet 10Base-T networks as a native device.

2.6 WARNING LABELS AND SIGNS

A. Comply with requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

1. High-Voltage Warning Label: Provide self-adhesive warning signs on outside of high-voltage compartment door(s). Sign legend shall be "DANGER HIGH VOLTAGE" printed in two lines of nominal 2-inch- ((50-mm)-)high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background.
2. Arc Flash Warning Label: Provide self-adhesive warning signs on outside of high-voltage compartment door(s), warning of potential electrical arc flash hazards and appropriate personal protective equipment required.

2.7 SOURCE QUALITY CONTROL

A. Provide manufacturer's certificate that the transformer design tests comply with IEEE C57.12.90.

1. Perform the following factory-certified routine tests on each transformer for this Project:

a. Resistance.
b. Turns ratio, polarity, and phase relation.
c. Transformer no-load losses and excitation current at 100 percent of ratings.
d. Transformer impedance voltage and load loss.
e. Operation of all devices.
f. Lightning impulse.
g. Low frequency.
h. Leak.
i. Transformer no-load losses and excitation current at 110 percent of ratings.
j. Insulation power factor.
k. Applied potential, except that this test is not required for single-phase transformers or for three-phase Y-Y-connected transformers.
l. Induced potential.

m. Resistance measurements of all windings on rated voltage connection and at tap extreme connections.
n. Ratios on rated voltage connection and at tap extreme connections.
o. Polarity and phase relation on rated voltage connection.
p. No-load loss at rated voltage on rated voltage connection.
q. Exciting current at rated voltage on rated voltage connection.
r. Impedance.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine pad-mounted, liquid-filled, medium-voltage transformers upon delivery.

1. Upon delivery of transformers and prior to unloading, inspect equipment for any damage that may have occurred during shipment or storage.
2. Verify that tie rods and chains are undamaged and tight, and that all blocking and bracing is tight. Verify that there is no evidence of load shifting in transit, and that readings from transportation shock recorders, if equipped, are within manufacturer's recommendations.
3. Verify that there is no indication of external damage and no dents or scratches in doors and sill, tank walls, radiators and fins, or termination provisions.
4. Verify that there is no evidence of insulating-liquid leakage on transformer surfaces, at weld seams, on high- or low-voltage bushing parts, and at transformer base.
5. Verify that there is positive pressure or vacuum on tank. Check pressure gauge; it is required to read other than zero.
6. Compare transformers and accessories received with bill of materials to verify that shipment is complete. Verify that transformers and accessories conform with manufacturer's quotation and shop drawings. If shipment is incomplete or does not comply with Project requirements, notify manufacturer in writing immediately.
7. Verify presence of polychlorinated biphenyl content labeling.
8. Unload transformers carefully, observing all packing label warnings and handling instructions.
9. Open termination compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign material, and water or moisture.

B. Handling:

1. Handle transformers carefully, in accordance with manufacturer recommendations, to avoid damage to enclosure, termination compartments, base, frame, tank, and internal components. Do not subject transformers to impact, jolting, jarring, or rough handling.
2. Protect transformer termination compartments against entrance of dust, rain, and snow.
3. Transport transformers upright, to avoid internal stresses on core and coil mounting assembly and to prevent trapping air in windings. Do not tilt or tip transformers.
4. Verify that transformer weights are within rated capacity of handling equipment.
5. Use only manufacturer-recommended points for lifting, jacking, and pulling. Use all lifting lugs when lifting transformers.
6. Use jacks only at corners of tank base plate.

7. Use nylon straps of same length to balance and distribute weight when handling transformers with a crane.
8. Use spreaders or a lifting beam to obtain a vertical lift and to protect transformer from straps bearing against enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.
9. Exercise care not to damage tank base structure when handling transformer using skids or rollers. Use skids to distribute stresses over tank base when using rollers under large transformers.

C. Storage:

1. Store transformers in accordance with manufacturer's recommendations.
2. Transformers may be stored outdoors. If possible, store transformers at final installation locations on concrete pads. If dry concrete surfaces are unavailable, use pallets of adequate strength to protect transformers from direct contact with ground. Ensure transformer is level.
3. Ensure that transformer storage location is clean and protected from severe conditions. Protect transformers from dirt, water, contamination, and physical damage. Do not store transformers in presence of corrosive or explosive gases. Protect transformers from weather when stored for more than three months.
4. Store transformers with compartment doors closed.
5. Regularly inspect transformers while in storage and maintain documentation of storage conditions, noting any discrepancies or adverse conditions. Verify that an effective pressure seal is maintained using pressure gauges. Visually check for insulating-liquid leaks and rust spots.

D. Examine areas and space conditions for compliance with requirements for pad-mounted, liquid-filled, medium-voltage transformers and other conditions affecting performance of the Work.

E. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will cross section barriers to reach load or line lugs.

F. Examine concrete bases for suitable conditions for transformer installation.

G. Pre-Installation Checks:

1. Verify removal of any shipping bracing after placement.
2. Remove a sample of insulating liquid according to ASTM D 923. Insulating-liquid values shall comply with NETA ATS, Table 100.4. Sample shall be tested for the following:

    a. Dielectric Breakdown Voltage: ASTM D 877 or ASTM D 1816.
    b. Acid Neutralization Number: ASTM D 974.
    c. Specific Gravity: ASTM D 1298.
    d. Interfacial Tension: ASTM D 971.
    e. Color: ASTM D 1500.
    f. Visual Condition: ASTM D 1524.
    g. Water in Insulating Liquids: Comply with ASTM D 1533.
    h. Power Factor or Dissipation Factor: ASTM D 924.

H. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at transformer location.

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

3.2 INSTALLATION

A. Install transformers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

B. Transformer shall be installed level and plumb and shall tilt less than 1.5 degrees while energized.

C. Comply with requirements for vibration isolation and seismic control devices specified in Section 260529 "Hangers and Supports for Electrical Systems" and Section 260548.16 "Seismic Controls for Electrical Systems."

D. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and IEEE C2.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. For counterpoise, use tinned bare copper cable not smaller than No. 4/0 AWG, buried not less than 30 inches (765 mm) below grade interconnecting the grounding electrodes. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable, with no kinks or sharp bends.
2. Fence and equipment connections shall not be smaller than No. 4 AWG. Ground fence at each gate post and corner post and at intervals not exceeding 10 ft. (3050 mm). Bond each gate section to fence post using 1/8 by 1 inch (3 by 25 mm) flexible braided copper strap and clamps.
3. Make joints in grounding conductors and loops by exothermic weld or compression connector.
4. Terminate all grounding and bonding conductors on a common equipment grounding terminal on transformer enclosure.
5. Complete transformer tank grounding and lightning arrester connections prior to making any other electrical connections.

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1. Maintain air clearances between energized live parts and between live parts and ground for exposed connections in accordance with manufacturer recommendations.
2. Bundle associated phase, neutral, and equipment grounding conductors together within transformer enclosure. Arrange conductors such that there is not excessive strain that

could cause loose connections. Allow adequate slack for expansion and contraction of conductors.

C. Terminate medium-voltage cables in incoming section of transformers according to Section 260513 "Medium-Voltage Cables."

3.4 SIGNS AND LABELS

A. Comply with installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

B. Install warning signs as required to comply with 29 CFR 1910.269.

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 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. General Field-Testing Requirements:

   a. Comply with provisions of NFPA 70B Ch. "Testing and Test Methods."
   b. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
   c. After installing transformer but before primary is energized, verify that grounding system at the transformer is tested at specified value or less.
   d. After installing transformer and after electrical circuitry has been energized, test for compliance with requirements.
   e. Visual and Mechanical Inspection:

      1) Verify equipment nameplate data complies with Contract Documents.
      2) Inspect bolted electrical connections for high resistance using one of the following two methods:

         a) Use a low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
         b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.

   f. Remove and replace malfunctioning units and retest.

g. Prepare test and inspection reports. Record as-left set points of all adjustable devices.

2. Medium-Voltage Surge Arrester Field Tests:

a. Visual and Mechanical Inspection:

1) Inspect physical and mechanical condition.
2) Verify arresters are clean.
3) Verify that ground lead on each device is individually attached to a ground bus or ground electrode.

b. Electrical Test:

1) Perform an insulation-resistance test on each arrester, phase terminal-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to comply with recommended minimum insulation resistance listed in that table.
2) Perform a watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.

3. Liquid-Filled Transformer Field Tests:

a. Visual and Mechanical Inspection:

1) Test dew point of tank gases if applicable.
2) Inspect anchorage, alignment, and grounding.
3) Verify bushings are clean.
4) Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
5) Verify that liquid level in tanks is within manufacturer's published tolerances.
6) Perform specific inspections and mechanical tests recommended by manufacturer.
7) Verify presence of transformer surge arresters and that their ratings are as specified.
8) Verify that as-left tap connections are as specified.

b. Electrical Tests:

1) Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; the value of the index shall not be less than 1.0.
2) Perform power-factor or dissipation-factor tests on all windings according to test equipment manufacturer's published data. Maximum winding insulation power-factor/dissipation-factor values shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.3.

3) Measure core insulation resistance at 500-V dc if the core is insulated and the core ground strap is removable. Core insulation-resistance values shall not be less than 1 megohm at 500-V dc.
4) Perform a power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV.
5) Perform turns-ratio tests at tap positions. Turns-ratio test results shall not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
6) Perform an excitation-current test on each phase. The typical excitation-current test data pattern for a three-legged core transformer is two similar current readings and one lower current reading. Investigate and correct if test shows a different pattern.
7) Measure resistance of each winding at each tap connection, and record temperature-corrected winding-resistance values in the Operations and Maintenance Manual.
8) Perform an applied-voltage test on high- and low-voltage windings-to-ground. Comply with IEEE C57.12.91, Sections 10.2 and 10.9. This test is not required for single-phase transformers and for three-phase Y-Y-connected transformers.
9) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
10) Remove a sample of insulating liquid according to ASTM D 923, and perform dissolved-gas analysis according to IEEE C57.104 or ASTM D 3612.

3.6 FOLLOW-UP SERVICE

A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:

1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the outgoing section of each transformer. Use voltmeters with calibration traceable to the National Institute of Science and Technology standards and with a chart speed of not less than 1 inch (25 mm) per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during test period, is unacceptable.
2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:

    a. Adjust transformer taps.
    b. Prepare written request for voltage adjustment by electric utility.

3. Retests: Repeat monitoring, after corrective action is performed, until satisfactory results are obtained.
4. Report:

    a. Prepare a written report covering monitoring performed and corrective action taken.

B. Infrared Inspection: Perform survey during periods of maximum possible loading. Remove all necessary covers prior to inspection.

1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of transformer's electrical power connections.
2. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1?C at 30?C.
3. Record of Infrared Inspection: Prepare a certified report that identifies testing technician and equipment used, and lists results as follows:

    a. Description of equipment to be tested.
    b. Discrepancies.
    c. Temperature difference between area of concern and reference area.
    d. Probable cause of temperature difference.
    e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
    f. Identify load conditions at time of inspection.
    g. Provide photographs and thermograms of deficient area.

4. Act on inspection results according to recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems.

END OF SECTION 261219

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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes: Distribution, dry-type transformers rated 600 V and less, with capacities up to 1500 kVA.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.

B. Shop Drawings:

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. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For transformers, 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.

B. Qualification Data: For testing agency.

C. Source quality-control reports.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. General Electric Company.
3. Siemens Power Transmission & Distribution, Inc.
4. Square D; by Schneider Electric.

B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Transformers Rated 15 kVA and Larger: Comply with NEMA TP 1 energy-efficiency levels as verified by testing according to NEMA TP 2.

D. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

E. Coils: Continuous windings without splices except for taps.

1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Copper.

F. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

G. Shipping Restraints: Paint or otherwise color code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: Ventilated.

1. NEMA 250, Type 2: Core and coil shall be encapsulated within resin compound utilizing a vacuum pressure impregnation process to seal out moisture and air.
2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.

E. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: Gray.

F. Taps for Transformers 3 kVA and Smaller: One 5 percent tap above normal full capacity.

G. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

I. Insulation Class, Smaller than 30 kVA: 185 deg C, UL-component-recognized insulation system with a maximum of 115-deg C rise above 40-deg C ambient temperature.

J. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 115-deg C rise above 40-deg C ambient temperature.

K. 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.
3. Unit shall meet requirements of NEMA TP 1 when tested according to NEMA TP 2 with a K-factor equal to one.

L. 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.

M. Neutral: Rated 200 percent of full load current for K-factor rated transformers.

N. Wall Brackets: Wall brackets fabricated from design drawings signed and sealed by a licensed structural engineer.

O. Fungus Proofing: Permanent fungicidal treatment for coil and core.

P. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:

1. 9 kVA and Less: 40 dBA
2. 30 to 50 kVA: 45 dBA
3. 51 to 150 kVA: 50 dBA
4. 151 to 300 kVA: 55 dBA
5. 301 to 500 kVA: 60 dBA
6. 501 to 750 kVA: 62 dBA
7. 751 to 1000 kVA: 64 dBA
8. 1001 to 1500 kVA: 65 dBA

2.4 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.

1. Resistance measurements of all windings at the rated voltage connections and at all tap connections.
2. Ratio tests at the rated voltage connections and at all tap connections.
3. Phase relation and polarity tests at the rated voltage connections.
4. No load losses, and excitation current and rated voltage at the rated voltage connections.
5. Impedance and load losses at rated current and rated frequency at the rated voltage connections.

6. Applied and induced tensile tests.
7. Regulation and efficiency at rated load and voltage.
8. Insulation Resistance Tests:

    a. High-voltage to ground.
    b. Low-voltage to ground.
    c. High-voltage to low-voltage.

9. Temperature tests.

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. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

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

3.2 INSTALLATION

A. Install wall-mounted transformers level and plumb with wall brackets fabricated from design drawings signed and sealed by a licensed structural engineer.

1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
2. Brace wall-mounted transformers as specified in Section 260548.16 "Seismic Controls for Electrical Systems."

B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

C. Construct concrete bases according to Section 033000 "Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions, seismic codes

applicable to Project, and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

1. 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.

D. Secure transformer to concrete base according to manufacturer's written instructions.

E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

F. Remove shipping bolts, blocking, and wedges.

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."

C. 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.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

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. 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 each visual and mechanical inspection and electrical test stated in NETA ATS for dry-type, air-cooled, low-voltage transformers. Certify compliance with test parameters.

E. Remove and replace units that do not pass tests or inspections and retest as specified above.

F. 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 two follow-up infrared scans of transformers, one at four 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.

G. 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 5 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.

C. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262200

SECTION 262300 - LOW-VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes metal-enclosed, low-voltage power circuit-breaker switchgear rated 1000 V and less for use in ac systems.

B. Related Sections include the following:

1. Section 260913 "Electrical Power Monitoring and Control" for interfacing communication and metering requirements.

1.3 DEFINITIONS

A. ATS: Acceptance Testing Service.

B. GFCI: Ground-fault circuit interrupter.

1.4 ACTION 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. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Wiring Diagrams: Power, signal, and control wiring.

C. Samples: Representative portion of mimic bus with specified finish. Manufacturer's color charts showing colors available for mimic bus.

1.5 INFORMATIONAL SUBMITTALS

A. 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.

B. Manufacturer Seismic Qualification Certification: Submit certification that switchgear, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Section 260548.16 "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.

C. Qualification Data: For testing agency.

D. Field quality-control test reports.

E. Updated mimic-bus diagram reflecting field changes after final switchgear load connections have been made, for record.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchgear and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: 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 (250 mL).

1.8 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. Refer to Section 016000 "Product Requirements."

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.

1.9 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.

1.10 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 Construction Manager no fewer than thirty days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without 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 40 deg C.
2. Altitude: Not exceeding 6600 feet (2010 m).

1.11 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 with concrete.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB Inc.
2. Cutler-Hammer, Inc.
3. General Electric Company.
4. Siemens Industry, Inc.
5. Square D; by Schneider Electric.

2.2 RATINGS

A. Nominal System Voltage: 480/277 V, 4 wire, 60 Hz.

B. Main-Bus Continuous: 3200 A.

C. Short-Time and Short-Circuit Current: Match rating of highest-rated circuit breaker in switchgear assembly.

2.3 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 (200-km/h) 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.
6. Weatherproof duplex receptacle.
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.
2. Neutral Bus: 100 percent of phase-bus ampacity, except as indicated. Equip bus with pressure-connector terminations for outgoing circuit neutral conductors. Include braces for neutral-bus extensions for busway feeders.
3. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.
4. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.
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 (6 by 50 mm).
9. Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents.
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 (6-by-50-mm) 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 (0.08 mm), minimum.
    b. Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.

2.4 COMPONENTS

A. Instrument Transformers: Comply with IEEE C57.13.

1. Potential Transformers: Secondary-voltage rating of 120 V 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. Analog Instruments: Rectangular, 4-1/2-inch (115-mm) 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, 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.

C. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.

D. Surge Arresters: Distribution class, metal-oxide-varistor type. Comply with IEEE C62.11 and NEMA LA 1.

1. Install in cable termination compartments and connect in each phase of circuit.
2. Coordinate rating with circuit voltage.

E. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.

F. Fungus Proofing: Permanent fungicidal treatment for switchgear interior, including instruments and instrument transformers.

G. Control Power Supply: Control power transformer supplying 120-V 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.

3. Control Power Fuses: Primary and secondary fuses with current-limiting and overload protection.
4. Fuses are specified in Section 262813 "Fuses."

H. 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.

2.5 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.
3. Stored-Energy Mechanism: Electrically charged, with optional manual charging.
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 minus 5 to plus 40 deg C.
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."
6. Pickup Points: Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I^2t operation.
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: Instantaneous, with adjustable pickup voltage.

N. Undervoltage Trip Devices: Adjustable time-delay and pickup voltage.

O. Shunt-Trip Devices: Where indicated.

P. 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.

Q. 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.

2.6 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.

B. Circuit-Breaker Removal Apparatus: Portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments.

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.

2.7 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 Architect.
3. Color: Contrasting with factory-finish background; as selected by Architect 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 (100-mm), channel-iron floor sill embedded in concrete base and attach by bolting.

1. Sills: Select to suit switchgear; level and grout flush into concrete base.
2. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Section 260548.16 "Seismic Controls for Electrical Systems" for seismic-restraint requirements.
3. Concrete Bases: 6 inches (150 mm) high, reinforced, with chamfered edges. Extend base no more than 6 inches (150 mm) 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 Section 260573 "Overcurrent Protective Device Coordination Study."

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. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 262300

SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Surge protection devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.
7. Identification.
8. Mimic bus.

1.3 ACTION SUBMITTALS

A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.

1. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
6. Detail utility company's metering provisions with indication of approval by utility company.
7. Include evidence of NRTL listing for series rating of installed devices.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

9. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
10. Include diagram and details of proposed mimic bus.
11. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Samples: Representative portion of mimic bus with specified material and finish, for color selection.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Certificates: For switchboards, overcurrent protective devices, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Routine maintenance requirements for switchboards and all installed components.
b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.6 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. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type but no fewer than two of each size and type.
2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
4. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
6. Indicating Lights: Equal to 10 percent of quantity installed for each size and type but no less than one of each size and type.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) to prevent condensation.

C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.9 FIELD 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 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 (40 deg C).
   b. Altitude: Not exceeding 6600 feet (2000 m).

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager no fewer than thirty 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 Owner's written permission.
4. Comply with NFPA 70E.

1.10 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Substantial Completion.

B. Manufacturer's Warranty: Manufacturer's agrees to repair or replace surge protection 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 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.
2. 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."

2.2 SWITCHBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. General Electric Company.
3. Siemens Power Transmission & Distribution, Inc.
4. Square D; by Schneider Electric.

B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. 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.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NEMA PB 2.

F. Comply with NFPA 70.

G. Comply with UL 891.

H. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

I. Nominal System Voltage: 480Y/277 V.

J. Main-Bus Continuous: 400 A.

K. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.

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."
b. 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."

L. Outdoor Enclosures: Type 3R.

1. Finish: Factory-applied finish in manufacturer's standard color; undersurfaces treated with corrosion-resistant undercoating.
2. Enclosure: Downward, rearward sloping roof; bolt-on rear covers for each section, with provisions for padlocking.
3. Doors: Personnel door at each end of aisle, minimum width of 30 inches (762 mm); opening outwards; with panic hardware and provisions for padlocking. At least one door shall be sized to permit the largest single switchboard section to pass through without disassembling doors, hinges, or switchboard section.
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. Retain one of two subparagraphs below. Retain first subparagraph to require switchboard manufacturer to provide power through a control transformer. Retain second if power from a remote source is indicated on Drawings. Coordinate with Drawings.

6. Power for Space Heaters, Ventilation, Lighting, and Receptacle: Include a control-power transformer, with spare capacity of 25 percent, within the switchboard. Supply voltage shall be 120 V ac.

M. Barriers: Between adjacent switchboard sections.

N. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

O. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.

1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point.
2. Space-Heater Power Source: Transformer, factory installed in switchboard.

P. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.

Q. Utility Metering Compartment: Barrier compartment and section complying with utility company's requirements; hinged sealable 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.

R. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, 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.

S. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

T. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws, for access to rear interior of switchboard.

U. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

V. 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.

W. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated.
3. Phase- and Neutral-Bus Material: Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
4. Copper feeder circuit-breaker line connections.
5. Tin-plated aluminum feeder circuit-breaker line connections.
6. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with compression connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
7. Ground Bus: 1/4-by-2-inch- (6-by-50-mm-) as required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with compression connectors for feeder and branch-circuit ground conductors.
8. 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.
9. Disconnect Links:

a. Isolate neutral bus from incoming neutral conductors.
b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.

10. Neutral Buses: 50 percent of the ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
11. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
12. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

X. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

Y. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.

Z. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

2.3 SURGE PROTECTION DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. General Electric Company.
3. Siemens Power Transmission & Distribution, Inc.
4. Square D; by Schneider Electric.

B. SPDs: Comply with UL 1449, Type 1.

C. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 1.

1. SPDs with the following features and accessories:

a. Integral disconnect switch.
b. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
c. Indicator light display for protection status.
d. Form-C contacts rated at 2 A and 24-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
e. Surge counter.

D. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 200 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

E. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V.
2. Line to Ground: 1200 V for 480Y/277 V.
3. Line to Line: 2000 V for 480Y/277 V.

F. SCCR: Equal or exceed 200 kA.

G. Nominal Rating: 20 kA.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

    a. Instantaneous trip.
    b. Long- and short-time pickup levels.
    c. Long and short time 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 double-pole configurations with Class A ground-fault protection (6-mA trip).
7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
8. MCCB Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.
    b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor material.
    c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
    d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
    f. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."

g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
i. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

2.5 INSTRUMENTATION

A. Instrument Transformers: NEMA EI 21.1, and the following:

1. Potential Transformers: NEMA EI 21.1; 120 V, 60 Hz, single secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, secondary; wound type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:

a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.
d. Megawatts: Plus or minus 1 percent.
e. Megavars: Plus or minus 1 percent.
f. Power Factor: Plus or minus 1 percent.
g. Frequency: Plus or minus 0.1 percent.
h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.
j. Contact devices to operate remote impulse-totalizing demand meter.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

C. Analog Meters:

1. Meters: 4-inch (100-mm) diameter or 6 inches (150 mm) square, flush or semiflush, with anti-parallax 250-degree scales and external zero adjustment.

D. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.

E. 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.

F. Ammeters: 2-1/2-inch (64-mm) 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.

G. Watt-Hour Meters and Wattmeters:

1. Comply with ANSI C12.1.
2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
3. Suitable for connection to three- and four-wire circuits.
4. Potential indicating lamps.
5. Adjustments for light and full load, phase balance, and power factor.
6. Four-dial clock register.
7. Integral demand indicator.
8. Contact devices to operate remote impulse-totalizing demand meter.
9. Ratchets to prevent reverse rotation.
10. Removable meter with drawout test plug.
11. Semiflush mounted case with matching cover.
12. Appropriate multiplier tag.

H. Impulse-Totalizing Demand Meter:

1. Comply with ANSI C12.1.
2. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.
3. Cyclometer.
4. Four-dial, totalizing kilowatt-hour register.
5. Positive chart drive mechanism.
6. Capillary pen holding a minimum of one month's ink supply.
7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
8. Capable of indicating and recording 15-minute integrated 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. Control Circuits: 24V dc.

D. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.

E. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

F. 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.

C. Portable Circuit-Breaker Lifting Device: Floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.

D. Overhead Circuit-Breaker Lifting Device: Mounted at top front of switchboard, with hoist and lifting yokes matching each drawout circuit breaker.

E. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

F. Mounting Accessories: For anchors, mounting channels, bolts, washers, and other mounting accessories, comply with requirements in Section 260548.16 "Seismic Controls for Electrical Systems" or manufacturer's instructions.

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- (0.813-mm-) 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- (1.588 mm-) thick laminated plastic (Gravoply), located at eye level on front cover of the switchboard incoming service section.

C. Mimic Bus: Continuously integrated mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram.

D. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.

E. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.

F. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.

1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.
2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
3. Protect from moisture, dust, dirt, and debris during storage and installation.
4. Install temporary heating during storage per manufacturer's instructions.

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 or that affect the performance of the equipment.

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

3.2 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches (50-mm) above concrete base after switchboard is anchored in place.

2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to switchboards.
6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements specified in Section 260548.16 "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, surge protection devices, and instrumentation.

1. Set field-adjustable switches and circuit-breaker trip ranges.

H. Install spare-fuse cabinet.

I. Comply with NECA 1.

3.3 CONNECTIONS

A. Comply with requirements for terminating feeder bus specified in Section 262500 "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.

B. Comply with requirements for terminating cable trays specified in Section 260536 "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.

C. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.

D. Support and secure conductors within the switchboard according to NFPA 70.

E. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3.4 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 a 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."

3.5 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 the following tests and inspections with the assistance of a factory-authorized service representative:

1. Acceptance Testing:

    a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
    b. Test continuity of each circuit.

2. Test ground-fault protection of equipment for service equipment per NFPA 70.
3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
5. 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.

6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Switchboard will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as indicated.

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

END OF SECTION 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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.

1.3 DEFINITIONS

A. ATS: Acceptance testing specification.

B. GFCI: Ground-fault circuit interrupter.

C. GFEP: Ground-fault equipment protection.

D. HID: High-intensity discharge.

E. MCCB: Molded-case circuit breaker.

F. SPD: Surge protective device.

G. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.

1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
2. 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.
2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.

3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Include evidence of NRTL listing for SPD as installed in panelboard.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include wiring diagrams for power, signal, and control wiring.
9. Key interlock scheme drawing and sequence of operations.
10. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Panelboard Schedules: For installation in panelboards.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: Two spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI and GFEP Types: Two spares for each panelboard.
3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.10 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Not exceeding 23 deg F (minus 5 deg C) to plus 104 deg F (plus 40 deg C).
    b. Altitude: Not exceeding 6600 feet (2000 m).

B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager no fewer than thirty days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Owner's written permission.
3. Comply with NFPA 70E.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: 18 months from date of Substantial Completion.

B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.

1. SPD Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS AND LOAD CENTERS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

B. 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.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

F. Enclosures: Flush and Surface-mounted, dead-front cabinets.

1. Rated for environmental conditions at installed location.

    a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
    b. Outdoor Locations: NEMA 250, Type 3R.
    c. 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 5.

2. Height: 84 inches (2.13 m) maximum.
3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
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: galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
    b. Back Boxes: Galvanized steel.
    c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

G. Incoming Mains:
1. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

H. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.

    a. Plating shall run entire length of bus.
    b. Bus shall be fully rated the entire length.

2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
5. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled by an NRTL acceptable to authority having jurisdiction, as suitable for nonlinear loads in electronic-grade panelboards and others designated on Drawings. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter.
6. Split Bus: Vertical buses divided into individual vertical sections.

I. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
8. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.
9. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

J. NRTL Label: Panelboards or load centers shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards or load centers shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

K. Future Devices: Panelboards shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

1. Percentage of Future Space Capacity: 20 percent.

L. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards 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."

B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 2.

2.3 POWER PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. General Electric Company; GE Energy Management - Electrical Distribution.
3. Siemens Energy.
4. Square D; by Schneider Electric.

B. Panelboards: NEMA PB 1, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.

D. Mains: Circuit breaker.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. General Electric Company; GE Energy Management - Electrical Distribution.
3. Siemens Energy.
4. Square D; by Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

F. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. General Electric Company; GE Energy Management - Electrical Distribution.
3. Siemens Energy.
4. Square D; by Schneider Electric.

B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:

   a. Inverse time-current element for low-level overloads.
   b. Instantaneous magnetic trip element for short circuits.
   c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Circuit Breakers:

   a. RMS sensing.
   b. Field-replaceable rating plug or electronic trip.
   c. Digital display of settings, trip targets, and indicated metering displays.
   d. Multi-button keypad to access programmable functions and monitored data.
   e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
   f. Integral test jack for connection to portable test set or laptop computer.
   g. Field-Adjustable Settings:

1) Instantaneous trip.
2) Long- and short-time pickup levels.
3) Long and short time adjustments.
4) Ground-fault pickup level, time delay, and I squared T response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
6. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
7. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
8. Subfeed Circuit Breakers: Vertically mounted.
9. MCCB Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Breaker handle indicates tripped status.
c. UL listed for reverse connection without restrictive line or load ratings.
d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
g. Communication Capability: 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."
h. Shunt Trip: 24-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
i. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
j. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.
k. Auxiliary Contacts: Two, SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
l. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
m. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
n. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
o. Multipole units enclosed in a single housing with a single handle.
p. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
q. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.6 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Directory card inside panelboard door, mounted in transparent card holder.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

D. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

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 panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

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. Comply with NECA 1.

C. Install panelboards and accessories according to NEMA PB 1.1.

D. Equipment Mounting:

1. Install panelboards on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Attach panelboard to the vertical finished or structural surface behind the panelboard.
3. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

G. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.

H. Mount panelboard cabinet plumb and rigid without distortion of box.

I. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

J. Mounting panelboards with space behind is recommended for damp, wet, or dirty locations. The steel slotted supports in the following paragraph provide an even mounting surface and the recommended space behind to prevent moisture or dirt collection.

K. Mount surface-mounted panelboards to steel slotted supports 1 1/4 inch (32 mm) in depth. Orient steel slotted supports vertically.

L. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.
2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

M. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

N. Install filler plates in unused spaces.

O. Stub four 1-inch (27-EMT) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-EMT) empty conduits into raised floor space or below slab not on grade.

P. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

Q. Mount spare fuse cabinet in accessible location.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

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. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:
1. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
c. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

E. Panelboards will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as indicated

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.

1. Measure loads during period of normal facility operations.
2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.6 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416

SECTION 262713 - ELECTRICITY METERING

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 equipment for electricity metering by utility company and electricity metering by Owner.

1.3 DEFINITIONS

A. KY Pulse: Term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay opening and closing in response to the rotation of the disk in the meter.

B. PC: Personal computer.

1.4 ACTION SUBMITTALS

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

B. Shop Drawings: For electricity-metering equipment.

1. Dimensioned plans and sections or elevation layouts.
2. Wiring Diagrams: For power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Application and operating software documentation.

2. Software licenses.
3. Software service agreement.
4. Hard copies of manufacturer's operating specifications, design user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy Submittal.

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.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Receive, store, and handle modular meter center according to NECA 400.

1.9 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Construction Manager no fewer than thirty days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Owner's written permission.

1.10 COORDINATION

A. Electrical Service Connections: Coordinate with utility companies and components they furnish as follows:

1. Comply with requirements of utilities providing electrical power services.
2. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

1.11 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 operating system. Upgrade shall include new or revised licenses for use of software.

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

PART 2 - PRODUCTS

2.1 EQUIPMENT FOR ELECTRICITY METERING BY UTILITY COMPANY

A. Meters will be furnished by utility company.

B. Current-Transformer Cabinets: Comply with requirements of electrical-power utility company.

C. Meter Sockets: Comply with requirements of electrical-power utility company.

D. Meter Sockets: Steady-state and short-circuit current ratings shall meet indicated circuit ratings.

2.2 EQUIPMENT FOR ELECTRICITY METERING BY OWNER

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Corporation.
2. E-Mon.
3. General Electric Company.
4. Siemens Energy.
5. Square D; by Schneider Electric.

B. General Requirements for Owner's Meters:

1. Comply with UL 1244.
2. Meters used for billing shall have an accuracy of 0.2 percent of reading, complying with requirements in ANSI C12.20.
3. Meters shall be certified by California Type Evaluation Program as complying with Title 4, California Code of Regulations, Article 2.2.
4. Enclosure: NEMA 250, Type 1 minimum, with hasp for padlocking or sealing.
5. Identification: Comply with requirements in Section 260553 "Identification for Electrical Systems."
6. Memory Backup: Self-contained to maintain memory throughout power outages of 72 hours, minimum.
7. Sensors: Current-sensing type, with current or voltage output, selected for optimum range and accuracy for meters indicated for this application.

    a. Type: Split and solid core.

8. Current-Transformer Cabinet: Listed or recommended by metering equipment manufacturer for use with sensors indicated.

C. Kilowatt-hour Meter: Electronic three-phase meters, measuring electricity used.

1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.

2. Display: LCD with characters not less than 0.25 inch (6 mm) high, indicating accumulative kilowatt-hours and current kilowatt load. Retain accumulated kilowatt-hour in a nonvolatile memory, until reset.
3. Display: Digital electromechanical counter, indicating accumulative kilowatt-hours.

D. Kilowatt-hour/Demand Meter: Electronic single- and three-phase meters, measuring electricity use and demand. Demand shall be integrated over a 15-minute interval.

1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
2. Display: LCD with characters not less than 0.25 inch (6 mm) high, indicating accumulative kilowatt-hours, current time and date, current demand, and historic peak demand, and time and date of historic peak demand. Retain accumulated kilowatt-hour and historic peak demand in a nonvolatile memory, until reset.

E. Data Transmission Cable: Transmit KY pulse data over Class 1 control-circuit conductors in raceway. Comply with Section 260523 "Control-Voltage Electrical Power Cables."

F. Software: PC based, a product of meter manufacturer, suitable for calculation of utility cost allocation.

1. Utility Cost Allocation: Automatically import energy-usage records to allocate energy costs for the following:
   a. At least seven buildings.

2. Tenant or Activity Billing Software: Automatically import energy-usage records to automatically compute and prepare activity demand and energy-use statements based on metering of energy use and peak demand. Maintain separate directory for each tenant's historical billing information. Prepare summary reports in user-defined formats and time intervals.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with equipment installation requirements in NECA 1.

B. Install meters furnished by utility company. Install raceways and equipment according to utility company's written requirements. Provide empty conduits for metering leads and extend grounding connections as required by utility company.

C. Install modular meter center according to NECA 400 switchboard installation requirements.

3.2 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Series Combination Warning Label: Self-adhesive type, with text as required by NFPA 70.
2. Equipment Identification Labels: Adhesive film labels with clear protective overlay. For residential meters, provide an additional card holder suitable for printed, weather-resistant card with occupant's name.

3.3 FIELD QUALITY CONTROL

A. 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.

B. Tests and Inspections:

1. Connect a load of known kilowatt rating, 1.5 kW minimum, to a circuit supplied by metered feeder.
2. Turn off circuits supplied by metered feeder and secure them in off condition.
3. Run test load continuously for eight hours minimum, or longer, to obtain a measurable meter indication. Use test-load placement and setting that ensures continuous, safe operation.
4. Check and record meter reading at end of test period and compare with actual electricity used, based on test-load rating, duration of test, and sample measurements of supply voltage at test-load connection. Record test results.

C. Electricity metering will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 262713

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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Straight-blade convenience, and tamper-resistant receptacles.
2. GFCI receptacles.
3. Twist-locking receptacles.
4. Pendant cord-connector devices.
5. Cord and plug sets.
6. Toggle switches.
7. Decorator-style convenience.
8. Wall plates.
9. Floor service outlets.
10. Service poles.

1.3 DEFINITIONS

A. Abbreviations of Manufacturers' Names:

1. Cooper: Cooper Wiring Devices; Division of Cooper Industries, Inc.
2. Hubbell: Hubbell Incorporated: Wiring Devices-Kellems.
3. Leviton: Leviton Mfg. Company, Inc.
4. Pass & Seymour: Pass& Seymour/Legrand.

B. BAS: Building automation system.

C. EMI: Electromagnetic interference.

D. GFCI: Ground-fault circuit interrupter.

E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

F. RFI: Radio-frequency interference.

G. UTP: Unshielded twisted pair.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. 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.

PART 2 - PRODUCTS

2.1 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.

D. Devices for Owner-Furnished Equipment:

1. Receptacles: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

E. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STRAIGHT-BLADE RECEPTACLES

A. Duplex Convenience Receptacles: 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).

B. Tamper-Resistant Convenience Receptacles: 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).

2. Description: Labeled and complying with NFPA 70, "Health Care Facilities" Article, "Pediatric Locations" Section.

2.3 GFCI RECEPTACLES

A. General Description:

1. 125 V, 20 A, straight blade, non-feed-through type.
2. Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 943 Class A, and FS W-C-596.
3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).

C. Tamper-Resistant, Duplex GFCI Convenience Receptacles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Hubbell Incorporated; Wiring Device-Kellems.
b. Pass & Seymour/Legrand (Pass & Seymour).

2.4 TWIST-LOCKING RECEPTACLES

A. Twist-Lock, Single Convenience Receptacles: 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.

B. Twist-Lock, Isolated-Ground, Single Convenience Receptacles: 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).

2. Grounding: 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.

2.5 PENDANT CORD-CONNECTOR DEVICES

A. Description:

1. Matching, locking-type plug and receptacle body connector.
2. NEMA WD 6 Configurations L5-20P and L5-20R, heavy-duty grade, and FS W-C-596.
3. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.
4. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.6 CORD AND PLUG SETS

A. Description:

1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.

2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.7 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120/277 V, 20 A:

1. Single Pole:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Eaton (Arrow Hart).
2) Hubbell Incorporated; Wiring Device-Kellems.
3) Leviton Manufacturing Co., Inc.
4) Pass & Seymour/Legrand (Pass & Seymour).

2. Two Pole:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Eaton (Arrow Hart).
2) Hubbell Incorporated; Wiring Device-Kellems.
3) Leviton Manufacturing Co., Inc.
4) Pass & Seymour/Legrand (Pass & Seymour).

C. Key-Operated Switches: 120/277 V, 20 A.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).

2. Description: Single pole, with factory-supplied key in lieu of switch handle.

2.8 DECORATOR-STYLE DEVICES

A. Convenience Receptacles: Square face, 125 V, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, and UL 498.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Eaton (Arrow Hart).
    b. Hubbell Incorporated; Wiring Device-Kellems.
    c. Leviton Manufacturing Co., Inc.
    d. Pass & Seymour/Legrand (Pass & Seymour).

B. Tamper-Resistant Convenience Receptacles: Square face, 125 V, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, and UL 498.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Eaton (Arrow Hart).
    b. Hubbell Incorporated; Wiring Device-Kellems.
    c. Leviton Manufacturing Co., Inc.
    d. Pass & Seymour/Legrand (Pass & Seymour).

2. Description: Labeled to comply with NFPA 70, "Receptacles, Cord Connectors, and Attachment Plugs (Caps)" Article, "Tamper-Resistant Receptacles in Dwelling Units" Section.

C. Tamper-Resistant and Weather-Resistant Convenience Receptacles: Square face, 125 V, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, and UL 498.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Eaton (Arrow Hart).
    b. Hubbell Incorporated; Wiring Device-Kellems.
    c. Leviton Manufacturing Co., Inc.
    d. Pass & Seymour/Legrand (Pass & Seymour).

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, Non-Feed-Through Type, Convenience Receptacles: Square face, 125 V, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, UL 498, and UL 943 Class A.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Eaton (Arrow Hart).
    b. Hubbell Incorporated; Wiring Device-Kellems.
    c. Leviton Manufacturing Co., Inc.
    d. Pass & Seymour/Legrand (Pass & Seymour).

E. GFCI, Tamper-Resistant and Weather-Resistant Convenience Receptacles: Square face, 125 V, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, UL 498, and UL 943 Class A.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Pass & Seymour/Legrand (Pass & Seymour).

2. Description: Labeled to comply with NFPA 70, "Receptacles, Cord Connectors, and Attachment Plugs (Caps)" Article, "Tamper-Resistant Receptacles in Dwelling Units" Section.

F. Toggle Switches: Square Face, 120/277 V, 15 A; comply with NEMA WD 1, UL 20, and FS W-S-896.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).

2.9 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 0.05-inch- (1.2-mm-) thick, anodized aluminum, but coordinate with Architect.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant thermoplastic with lockable cover.

2.10 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: Rectangular, die-cast aluminum 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 complying with requirements in Section 271500 "Communications Horizontal Cabling."

2.11 SERVICE POLES

A. Description:

1. Factory-assembled and -wired units to extend power and voice and data communication from distribution wiring concealed in ceiling to devices or outlets in pole near floor.
2. Poles: Nominal 2.5-inch- (65-mm-) square cross section, with height adequate to extend from floor to at least 6 inches (150 mm) above ceiling, and with separate channels for power wiring and voice and data communication cabling.
3. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.
4. Finishes: Manufacturer's standard painted finish and trim combination.
5. Wiring: Sized for minimum of five No. 12 AWG power and ground conductors and a minimum of four, four-pair, Category 3 or Category 5 voice and data communication cables.
6. Power Receptacles: Two duplex, 20-A, straight-blade receptacles complying with requirements in this Section.
7. Voice and Data Communication Outlets: Four RJ-45 jacks complying with requirements in Section 271500 "Communications Horizontal Cabling."

2.12 FINISHES

A. Device Color:

1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Power System: Red.

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. Provide vandal resistant / tamper resistant devices for all Detention Housing buildings or any rooms where devices are accessible to inmates.

C. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

D. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

    a. Cut back and pigtail, or replace all damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

E. 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 (152 mm) 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.

F. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right.

G. 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.

H. 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.

I. 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.

J. 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 for normal, blue for UPS and red for emergency, lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 FIELD QUALITY CONTROL

A. Test Instruments: Use instruments that comply with UL 1436.

B. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. In healthcare facilities, prepare reports that comply with recommendations in NFPA 99.
2. Test Instruments: Use instruments that comply with UL 1436.
3. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

D. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.

5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

E. Test straight-blade convenience outlets in patient-care areas for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz. (115 g).

F. Wiring device will be considered defective if it does not pass tests and inspections.

G. 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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in the following:

    a. Control circuits.
    b. Enclosed controllers.
    c. Enclosed switches.

2. Spare-fuse cabinets.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

    a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
    b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
3. Current-limitation curves for fuses with current-limiting characteristics.
4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in electronic format suitable for use in coordination software and in PDF format].
5. Coordination charts and tables and related data.
6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017700 "Closeout Procedures," and Section 017823 "Operation and Maintenance Data," include the following:

1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit in electronic format suitable for use in coordination software and in PDF format.
4. Coordination charts and tables and related data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.6 FIELD CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bussmann, an Eaton business.
2. Edison; a brand of Bussmann by Eaton.
3. Littelfuse, Inc.
4. Mersen USA.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

1. Type RK-1: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
2. Type RK-5: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
3. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, fast acting.
4. Type CD: 600-V, 31- to 60-A rating, 200 kAIC, fast acting.
5. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
6. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.
7. Type T: 600-V, zero- to 800-A rating, 200 kAIC, very fast acting.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.3 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) 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. Large Motor Branch (601-4000 A): Class L, time delay.
   2. Other Branch Circuits: Class RK1, time delay.
   3. Control Transformer Circuits: Class CC, time delay, control transformer duty.
   4. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Owner.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of 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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Molded-case circuit breakers (MCCBs).
4. Molded-case switches.
5. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).

4. Include evidence of NRTL listing for series rating of installed devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Manufacturer's field service report.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Fuse Pullers: Two for each size and type.

1.9 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NFPA 70.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
2. Altitude: Not exceeding 6600 feet (2010 m).

B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager no fewer than thirty 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 Owner's written permission.
4. Comply with NFPA 70E.

1.11 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB Inc.
2. Eaton.
3. General Electric Company.
4. Siemens Industry, Inc.
5. Square D; by Schneider Electric.

B. Type GD, General Duty, Single Throw, 240-V ac, 800 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with cartridge fuse interiors to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

E. Type HD, Heavy Duty, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

F. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.

7. Lugs: Mechanical type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.
9. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.2 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. General Electric Company.
3. Siemens Industry, Inc.
4. Square D; by Schneider Electric.

B. Type GD, General Duty, Single Throw, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

E. Type HD, Heavy Duty, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

F. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
4. Hookstick Handle: Allows use of a hookstick to operate the handle.
5. Lugs: Compression type, suitable for number, size, and conductor material.
6. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.3 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. General Electric Company.

3. Siemens Industry, Inc.
4. Square D; by Schneider Electric.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

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. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
4. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
5. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
6. Alarm Switch: One NC contact that operates only when circuit breaker has tripped.
7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
8. Electrical Operator: Provide remote control for on, off, and reset operations.
9. Accessory Control Power Voltage: Integrally mounted, self-powered;.

2.4 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
6. Hazardous Areas Indicated on Drawings: NEMA 250, Type 9.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Section 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.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

E. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges.

END OF SECTION 262816

SECTION 262913 - ENCLOSED CONTROLLERS

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 the following enclosed controllers rated 600 V and less:

1. Full-voltage controllers.

1.3 DEFINITIONS

A. CPT: Control power transformer.

B. MCCB: Molded-case circuit breaker.

C. MCP: Motor circuit protector.

D. N.C.: Normally closed.

E. N.O.: Normally open.

F. OCPD: Overcurrent protective device.

G. SCR: Silicon-controlled rectifier.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed controllers 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 ACTION SUBMITTALS

A. Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.

B. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.

1. Show tabulations of the following:

a. Each installed unit's type and details.
b. Factory-installed devices.
c. Nameplate legends.
d. Short-circuit current rating of integrated unit.
e. Listed and labeled for integrated short-circuit current (withstand) rating of OCPDs in combination controllers by an NRTL acceptable to authorities having jurisdiction.
f. Features, characteristics, ratings, and factory settings of individual OCPDs in combination controllers.

2. Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: For enclosed controllers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

D. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

E. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for enclosed controllers and installed components.
2. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.

3. Manufacturer's written instructions for setting field-adjustable overload relays.
4. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage solid-state controllers.

1.8 MATERIALS MAINTENANCE SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses 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.
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. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.9 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

D. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

1.10 DELIVERY, STORAGE, AND HANDLING

A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install temporary electric heating, with at least 250 W per controller.

1.11 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 (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
2. Altitude: Not exceeding 6600 feet (2010 m).

B. Interruption of Existing Electrical Systems: Do not interrupt electrical systems in facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Construction Manager no fewer than two days in advance of proposed interruption of electrical systems.
2. Indicate method of providing temporary utilities.
3. Do not proceed with interruption of electrical systems without Owner's written permission.
4. Comply with NFPA 70E.

1.12 COORDINATION

A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, 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.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.1 FULL-VOLTAGE CONTROLLERS

A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.

B. Motor-Starting Switches: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Eaton.
b. General Electric Company.

c. Siemens Industry, Inc.
d. Square D; by Schneider Electric.

2. Configuration: Two speed.
3. Surface mounting.
4. Green pilot light.
5. Additional Nameplates: HIGH and LOW for two-speed switches.

C. Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton.
b. General Electric Company.
c. Siemens Industry, Inc.
d. Square D; by Schneider Electric.

2. Configuration: Two speed.
3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
4. Surface mounting.
5. Green pilot light.
6. Additional Nameplates: HIGH and LOW for two-speed controllers.

2.2 ENCLOSURES

A. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 3R.
3. Kitchen Areas: Type 4X, stainless steel.
4. Other Wet or Damp Indoor Locations: Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

2.3 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Standard-duty, type.

a. Push Buttons: Covered Lockable types; momentary as indicated.
b. Pilot Lights: LED types; colors as indicated; push to test.
c. Selector Switches: Rotary type.

2. Elapsed Time Meters: Heavy duty with digital readout in hours; resettable.
3. Meters: Panel type, 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale and plus or minus two percent accuracy. Where indicated, provide selector switches with an off position.

B. Reversible N.C./N.O. auxiliary contact(s).

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

D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

E. Breather and drain assemblies, to maintain interior pressure and release condensation in Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

F. Space heaters, with N.C. auxiliary contacts, to mitigate condensation in Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

G. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

H. Cover gaskets for Type 1 enclosures.

I. Terminals for connecting power factor correction capacitors to the load side of overload relays.

J. Spare control wiring terminal blocks, quantity as indicated; unwired.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.

B. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.

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

3.2 INSTALLATION

A. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

B. Floor-Mounted Controllers: Install enclosed controllers on 4-inch (100-mm) nominal-thickness concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of 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 supported equipment.

C. Seismic Bracing: Comply with requirements specified in Section 260548.16 "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 each fusible-switch enclosed controller.

F. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."

G. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

H. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

I. Install power factor correction capacitors. Connect to the load side of overload relays. If connected to the load side of overload relays, adjust overload heater sizes to accommodate the reduced motor full-load currents.

J. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified 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 nameplate.
3. Label each enclosure-mounted control and pilot device.

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers and remote devices and facility's central control system. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control selection devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
2. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

E. Tests and Inspections:

1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Construction Manager before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

8. Perform the following infrared (thermographic) 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 multi-pole enclosed controller. 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 multi-pole enclosed controller 11 months after date of Substantial Completion.
   c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Enclosed controllers 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 controllers 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 switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

B. Adjust overload-relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.

C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable instantaneous trip elements. Initially adjust to six times the motor nameplate full-load ampere ratings and attempt to start motors several times, allowing for motor cooldown between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Owner before increasing settings.

D. Set the taps on reduced-voltage autotransformer controllers at 80 percent.

E. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage solid-state controllers.

F. Set field-adjustable circuit-breaker trip ranges.

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.

B. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.

END OF SECTION 262913

SECTION 263100 - PHOTOVOLTAIC COLLECTORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. PV laminates (cells laminated into rigid sheets, with connecting cables).
2. PV modules (laminates in mounting frames).
3. Inverters.
4. Mounting structures.

1.3 DEFINITIONS

A. CEC: California Energy Commission.

B. ETFE: Ethylene tetrafluoroethylene.

C. FEP: Fluorinated ethylene propylene.

D. IP Code: Required ingress protection to comply with IEC 60529.

E. MPPT: Maximum power point tracking.

F. PTC: PVUSA Test Condition. Commonly regarded as a "real-world" measure of PV output. See below for definition of "PVUSA."

G. PV: Photovoltaic.

H. PVUSA: Photovoltaics for Utility Systems Applications.

I. STC: Standard Test Conditions defined in IEC 61215.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for PV panels.

2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For PV modules.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly.
4. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For manufacturer's special materials and workmanship warranty and minimum power output warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For PV modules to include in operation and maintenance manuals.

1.7 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of PV modules that fail in materials or workmanship within specified warranty period.

1. Manufacturer's materials and workmanship warranties include, but are not limited to, the following:

a. Faulty operation of PV modules.
b. Defective parts.

2. Warranty Period: Five years from date of Substantial Completion.

B. Manufacturer's Special Minimum Power Output Warranty: Manufacturer agrees to repair or replace components of PV modules that fail to exhibit the minimum power output within specified warranty period. Special warranty, applying to modules only, applies to materials only, on a prorated basis, for period specified.

1. Manufacturer's minimum power output warranties include, but are not limited to, the following warranty periods, from date of Substantial Completion:

a. Specified minimum power output to 80 percent or more, for a period of 25 years.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. BP Solar USA.
2. General Electric Company.
3. Mitsubishi Electric Corporation.
4. Sharp Electronics Corp.
5. SunPower Corporation.

2.2 PERFORMANCE REQUIREMENTS

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. Hazardous Locations: FM Global approved for NFPA 70, Class 1, Division 2, Group C and Group D.

C. Seismic Qualification Certificates: For equipment, 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.

2.3 PV SYSTEMS DESCRIPTION

A. Stand-Alone PV System: Collectors connected to provide power to Project dc and ac loads through an energy storage system.

1. A six-module array to generate a total nominal rated output of 1000 W.
2. System Components:

a. PV modules.
b. Array frame.
c. Charge controller.
d. Energy storage.
e. Inverter.
f. Overcurrent protection and disconnect devices.
g. Mounting structure.

2.4 MANUFACTURED PV UNITS

A. Cell Materials: Amorphous silicon (a-Si).

B. Cell Materials: Micromorphous silicon (a-Si+uc-Si).

C. Cell Materials: Copper indium (di)selenide (CIS).

D. Cell Materials: Copper indium gallium (di)selenide (CIGS).

E. Cell Materials: Cadmium telluride (CdTe).

F. Cell Materials: Cadmium sulfide.

G. Cell Materials: Polycrystalline.

1. c-Si.
2. Gallium arsenide (GaAs).

H. Module Construction:

1. Nominal Size: 32 inches (800 mm) wide by 64 inches (1600 mm) long.
2. Weight: 42.8 lb (19.4 kg).

I. Insulating Substrate Film: [**Flexible**] [**Rigid**], [**polyester**] [**polyimide**].

J. Conducting Substrate Film: [**Flexible**] [**Rigid**] [**Fluoropolymer**], [**ETFE**] [**FEP**].

K. Encapsulant: Ethyl vinyl acetate.

L. Front Panel: Fully tempered glass.

M. Front Panel: 0.125-inch- (3.2-mm-) thick glass.

N. Front Panel: Low iron glass.

O. Front Panel: Antireflective coating glass.

P. Front Panel: Laminating film.

Q. Front Panel: Laminating material.

R. Backing Material: Tempered glass.

S. Backing Material: 0.125-inch- (3.2-mm-) thick glass; color shall be by Architect.

T. Backing Material: Polyester film.

1. Layers: 2.
2. Color: White.

U. Bypass Diode Protection: Internal.

V. Junction Box:

1. Size: 1.56 by 3.96 by 0.52 inch (39.6 by 100.6 by 13.2 mm).
2. Fully potted, vandal resistant.
3. IP Code: [**IP65**] [**IP66**] [**IP67**]
4. Flammability Test: UL 1703.

W. Output Cabling:

1. 0.158 inch (4 mm).
2. Quick, multiconnect, polarized connectors.
3. Two-Conductor Harness: No traditional return wire is needed from the end of a row back to the source combiner.

X. Series Fuse Rating: <**Insert amperage**>.

2.5 PV CAPACITIES AND CHARACTERISTICS

A. Minimum Electrical Characteristics:

1. Rated Open-Circuit Voltage: <**Insert V dc**>.
2. Maximum System Voltage: <**Insert V dc**>.
3. Maximum Power at Voltage (Vpm): <**Insert V dc**>.
4. Short-Circuit Temperature Coefficient: <**Insert mA/deg C**>.
5. Rated Short-Circuit Current (Isc): <**Insert amperage**>.
6. Maximum System: <**Insert V dc**>.
7. Rated Operation Current (Imp): <**Insert amperage**>.
8. Maximum Power at STC (Pmax): <**Insert watts**>.

B. Additional Electrical Characteristics:

1. PTC Rating: <**Insert watts**>.
2. Peak Power per Unit Area: <**Insert watts**>.
3. Tolerance of Pmax: <**Insert number**> percent.
4. Minimum Peak Power: <**Insert watts**>.
5. Series Fuse Rating: <**Insert amperage**>.
6. Module Efficiency: <**Insert number**> percent.
7. Temperature Cycling Range: <**Insert deg C**>.
8. Humidity, Freeze, Damp Heat Condition: <**Insert number**> percent RH.
9. Wind Loading or Surface Pressure: <**Insert lbf/sq. ft. (N/sq. m)**>.
10. Maximum Distortion Angle: <**Insert degrees**>.
11. Hailstone Impact Withstand: <**Insert inches (mm)**> diameter at <**Insert mph (km/h)**> wind velocity.
12. Series Fuse Rating: <**Insert amperage**>.

C. Normal Operating Temperature Characteristics (NOTC):

1. Temperature at Nominal Operating Cell Temperature: <**Insert deg C**>.
2. Temperature Coefficient (NOTC Nominal Power): <**Insert deg C**>.
3. Temperature Coefficient (NOTC Open-Circuit Voltage): <**Insert deg C**>.

4. Temperature Coefficient (NOTC Short Circuit Current): <**Insert deg C**>.
5. Temperature Coefficient (NOTC Maximum Power Voltage): <**Insert deg C**>.
6. Temperature Coefficient (NOTC Maximum Power Current): <**Insert deg C**>.

2.6 PV MODULE FRAMING

A. PV laminates mounted in anodized extruded-aluminum frames.

1. Entire assembly UL listed for electrical and fire safety, [**Class A**] [**Class C**], according to UL 1703, and complying with IEC 61215.
2. Frame strength exceeding requirements of certifying agencies in subparagraph above.
3. Finish: Anodized aluminum.

    a. Alloy and temper recommended by framing manufacturer for strength, corrosion resistance, and application of required finish.
    b. Color: As indicated by manufacturer's designations.

4. Finish: High-performance organic finish.

    a. Fluoropolymer Two-Coat System: Manufacturer's standard two-coat, thermocured system consisting of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent PVC resin by weight.
    b. Color: As indicated by manufacturer's designations.

5. Finish: Baked-enamel finish.

    a. Color: As indicated by manufacturer's designations.

2.7 PV ARRAY CONSTRUCTION

A. Framing:

1. Material: Galvanized steel.
2. Maximum System Weight: Less than 4 lb/sq. ft. (19.53 kg/sq. m).
3. Minimum Distance to Connectors: <**Insert inches (mm)**>.
4. Raceway Cover Plates: Galvanized steel.

2.8 INVERTER

A. Inverter Type: [**Central**] [**Microgrid**].

B. Control Type: Pulse-width-modulation control.

C. Control Type: Maximum power point tracker control.

D. Inverter Electrical Characteristics:

1. Maximum Recommended PV Input Power: <**Insert kilowatts**>.
2. Maximum Open-Circuit Voltage: <**Insert V dc**>.

3. PV Start Voltage: <**Insert V dc**>.
4. MPPT Voltage Range: <**Insert V dc**>.
5. Maximum Input Current: <**Insert amperage**>.
6. Number of String Inputs: <**Insert number**>.
7. Number of Independent MPPT Circuits: <**Insert value**>.
8. Nominal Output Voltage: <**Insert V dc**>.
9. CEC Rated Power: <**Insert kilowatts**>.
10. Nominal Output Voltage: <**Insert V ac**>.
11. Maximum Output Current: <**Insert amperage**>.
12. Peak Efficiency: <**Insert number**> percent.
13. CEC Weighted Efficiency: <**Insert number**> percent.
14. CEC Night Tare Loss: <**Insert watts**>.
15. DC/AC Terminal Range (AWG): <**Insert range of AWG values**>.
16. Communications Interface: [**RS 485**] [**RS 232**] [**Ethernet**] [**Zigbee**] <**Insert type**>.
17. Utility Interface: Utility-interactive inverter.

E. Operating Conditions:

1. Operating Ambient Temperatures: Minus 4 to plus 122 deg F (20 to plus 50 deg C).
2. Storage Temperature: Minus 40 to plus 122 deg F (minus 40 to plus 50 deg C).
3. Relative Humidity: Zero to 95 percent, noncondensing.

F. Charge controllers shall have the following:

1. Overcurrent protection.
2. Generator input breaker box.
3. Automatic transfer relay.
4. Digital display.
5. Transformer.
6. Disconnect switch.
7. Shunt controller.
8. Shunt regulator.
9. Surge overload protection.

G. Enclosure:

1. NEMA 250, Type 3R.
2. Enclosure Material: Galvanized steel.
3. Cooling Methods:

    a. Fan convection cooling.
    b. Passive cooling.

4. Protective Functions:

    a. AC over/undervoltage.
    b. AC over/underfrequency.
    c. Ground overcurrent.
    d. Overtemperature.
    e. AC and dc overcurrent.
    f. DC overvoltage.

5. Standard LCD, four lines, 20 characters, with user display and on/off toggle switch.

H. Disconnects: Rated for system voltage and conductor.

I. Regulatory Approvals:

1. IEEE 1547.1.
2. IEEE 1547.3.
3. UL 1741.

J. Characteristics:

1. Inverter Dimensions: <**Insert inches (mm)**>.
2. Inverter Weight: <**Insert lb (kg)**>.

2.9 SYSTEM OVERCURRENT PROTECTION

A. Fuses: <**Insert amperage**>.

B. Circuit Breakers: <**Insert amperage**>.

2.10 MOUNTING STRUCTURES

A. Pole Mount: Top.

B. Tracking Mounts: Two axis.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrate areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Do not begin installation until mounting surfaces have been properly prepared.

C. If preparation of mounting surfaces is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

D. Examine modules and array frame before installation. Reject modules and arrays that are wet, moisture damaged, or mold damaged.

E. Examine roofs, supports, and supporting structures for suitable conditions where PV system will be installed.

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

3.2 INSTALLATION

A. Comply with NECA 1.

B. Coordinate layout and installation of PV panels with support assembly and other construction.

C. Support PV panel assemblies independent of supports for other elements such as roof and support assemblies, enclosures, vents, pipes, and conduits. Support assembly to prevent twisting from eccentric loading.

D. Install PV inverters, energy storage, charge controller, and system control in locations indicated on Drawings.

E. Install weatherseal fittings and flanges where PV panel assemblies penetrate exterior elements such as walls or roofs. Seal around openings to make weathertight. See Section 079200 "Joint Sealants" for materials and application.

F. Seismic Restraints: Comply with requirements for seismic-restraint devices specified in Section 260548.16 "Seismic Controls for Electric Systems."

G. Wiring Method: Install cables in raceways.

H. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.3 CONNECTIONS

A. Coordinate PV panel cabling to equipment enclosures to ensure proper connections.

B. Coordinate installation of utility-interactive meter with utility.

C. 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.

D. 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.

END OF SECTION 263100

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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes packaged engine-generator sets for emergency standby power supply with the following features:

1. Diesel engine.
2. Unit-mounted cooling system.
3. Unit-mounted control and monitoring.
4. Performance requirements for sensitive loads.
5. Fuel system.
6. Parallel generator sets.
7. Load banks.
8. Outdoor enclosure.

B. Related Requirements:

1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

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. EPS: Emergency power supply.

C. EPSS: Emergency power supply system.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Include thermal damage curve for generator.
3. Include time-current characteristic curves for generator protective device.

4. Include fuel consumption in gallons per hour at 0.8 power factor at 0.5, 0.75 and 1.0 times generator capacity.
5. Include air flow requirements for cooling and combustion air in cfm at 0.8 power factor, with air supply temperature of 95, 80, 70, and 50 deg F. Provide drawings showing requirements and limitations for location of air intake and exhausts.
6. Include generator characteristics, including, but not limited to kw rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:

1. Include plans and elevations for engine-generator set and other components specified. Indicate access requirements affected by height of sub base fuel tank.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and manufacturer.

B. Seismic Qualification Certificates: For engine-generator set, 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: With engine and generator mounted on rails identify center of gravity and total weight including full fuel tank, supplied enclosure, external silencer, sub base-mounted fuel tank, and each piece of equipment not integral to the engine-generator set, and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Source quality-control reports, including, but not limited to the following:

1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.

5. Report of sound generation.
6. Report of exhaust emissions showing compliance with applicable regulations.
7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

D. Field quality-control reports.

E. Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. 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.
b. Operating instructions laminated and mounted adjacent to generator location.
c. Training plan.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. 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.
4. Tools: Each tool listed by part number in operations and maintenance manual.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.9 WARRANTY

A. Manufacturer's Warranty: 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: 2 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Caterpillar; Engine Div.
2. Kohler Power Systems.
3. Onan/Cummins Power Generation; Industrial Business Group.

B. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Engine-generator set housing, subbase fuel tank, engine-generator set, batteries, battery racks, silencers, and sound attenuating equipment, accessories, and components 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 when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst case normal levels. Water shall be substituted for diesel fuel in fuel tank during test.
3. Component Importance Factor: 1.5.

B. ASME Compliance: Comply with ASME B15.1.

C. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.
3. Comply with NFPA 110 requirements for Level 1 emergency power supply system.

D. UL Compliance: Comply with UL 2200.

E. Engine Exhaust Emissions: Comply with EPA Tier 3 requirements and applicable state and local government requirements.

F. 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.

G. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: 5 to 40 deg C.
2. Altitude: Sea level to 1000 feet (300 m).

H. 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.

2.3 ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

C. EPSS Class: Engine-generator set shall be classified as a Class 72 in accordance with NFPA 110.

D. Induction Method: Naturally aspirated.

E. Governor: Adjustable isochronous, with speed sensing.

F. Emissions: Comply with EPA Tier 4 requirements.

G. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

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.

H. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries, 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.

I. 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 three-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.

J. Generator-Set Performance for Sensitive Loads:

1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.

    a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.

2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a three-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

A. Fuel: Fuel oil, Grade DF-2.

B. Rated Engine Speed: 1800 rpm.

C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).

D. Lubrication System: The following items are mounted on engine or skid:

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

E. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.

F. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.

a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and noncollapsible under vacuum.
b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

G. Muffler/Silencer: Critical 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 25 dB at 500 Hz.

2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 78 dBA or less.

H. Air-Intake Filter: Standard-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

I. Starting System: 24-V electric, with negative ground.

1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" 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: Lead acid, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least three times without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35 A minimum continuous rating.
9. Battery Charger: Current-limiting, automatic-equalizing and float-charging type designed for lead acid batteries. Unit shall comply with UL 1236 and include the following features:

    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg F (minus 40 deg C) to 140 deg F (plus 60 deg C) to prevent overcharging at high temperatures and undercharging at low temperatures.
    c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
    d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
    e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
    f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.5 DIESEL FUEL-OIL SYSTEM

A. Comply with NFPA 30.

B. Piping: Fuel-oil piping shall be Schedule 40 black steel. Cast iron, aluminum, copper, and galvanizing shall not be used in the fuel-oil system.

C. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions.

D. Fuel Filtering: Remove water and contaminants larger than 1 micron.

E. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

F. 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 72 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 control 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.

G. Subbase-Mounted, Double-Wall, Fuel-Oil Tank: Factory installed and piped, complying with UL 142 fuel-oil tank. Features include the following:

1. Tank level indicator.
2. Fuel-Tank Capacity: Minimum 133 percent of total fuel required for periodic maintenance operations between fuel refills, plus fuel for the hours of continuous operation for indicated EPSS class.
3. Leak detection in interstitial space.
4. Vandal-resistant fill cap.

5. Containment Provisions: Comply with requirements of authorities having jurisdiction.

2.6 GASEOUS FUEL SYSTEM

A. Natural-Gas Piping: Comply with requirements in Section 231123 "Facility Natural-Gas Piping."

B. LP-Gas Piping: Comply with requirements in Section 231126 "Facility Liquefied-Petroleum Gas Piping."

C. Gas Train: Comply with NFPA 37.

D. Engine Fuel System:

1. [**Dual Natural-Gas with LP-Gas Backup**] [**Natural-Gas**] [**LP-Gas**], Vapor-Withdrawal System:

a. Carburetor.
b. Secondary Gas Regulators: One for each fuel type, with atmospheric vents piped to building exterior.
c. Fuel-Shutoff Solenoid Valves: NRTL-listed, normally closed, safety shutoff valves; one for each fuel source.
d. Fuel Filters: One for each fuel type.
e. Manual Fuel Shutoff Valves: One for each fuel type.
f. Flexible Fuel Connectors: Minimum one for each fuel connection.
g. LP-gas flow adjusting valve.
h. Fuel change gas pressure switch.

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.

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.

C. Provide minimum run time control set for [**15**] [**30**] <**Insert number**> minutes with override only by operation of a remote emergency-stop switch.

D. Comply with UL 508A.

E. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages 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. Panel shall be powered from the engine-generator set battery.

F. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel. Panel shall be powered from the engine-generator set battery.

G. Configuration: Operating and safety indications, protective devices, basic system controls, engine gages, 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 shall be powered from the engine-generator set battery. Panel features shall include the following:

1. Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6. Power bus shall be copper. Bus, bus supports, control wiring, and temperature rise shall comply with UL 891.
2. Switchboard Construction: Freestanding unit complying with Section 262413 "Switchboards."
3. Switchgear Construction: Freestanding unit complying with Section 262300 "Low-Voltage Switchgear."

H. Indicating Devices : As required by NFPA 110 for Level [**1**] [**2**] system, including the following:

1. AC voltmeter.
2. AC ammeter.
3. AC frequency meter.
4. EPS supplying load indicator.
5. Ammeter and voltmeter phase-selector switches.
6. DC voltmeter (alternator battery charging).
7. Engine-coolant temperature gage.
8. Engine lubricating-oil pressure gage.
9. Running-time meter.
10. Current and Potential Transformers: Instrument accuracy class.

I. Protective Devices and Controls in Local Control Panel: Shutdown devices and common visual alarm indication as required by NFPA 110 for Level [**1**] [**2**] system, including the following:

1. Start-stop switch.
2. Overcrank shutdown device.
3. Overspeed shutdown device.
4. Coolant high-temperature shutdown device.
5. Coolant low-level shutdown device.
6. Low lube oil pressure shutdown device.
7. Air shutdown damper shutdown device when used.
8. Overcrank alarm.
9. Overspeed alarm.
10. Coolant high-temperature alarm.
11. Coolant low-temperature alarm.
12. Coolant low-level alarm.
13. Low lube oil pressure alarm.

14. Air shutdown damper alarm when used.
15. Lamp test.
16. Contacts for local and remote common alarm.
17. Coolant high-temperature prealarm.
18. Generator-voltage adjusting rheostat.
19. Main fuel tank low-level alarm.

    a. Low fuel level alarm shall be initiated when the level falls below that required for operation for the duration required in "Fuel Tank Capacity" Paragraph in "Diesel Fuel-Oil System" Article.

20. Run-Off-Auto switch.
21. Control switch not in automatic position alarm.
22. Low-starting air pressure alarm.
23. Low-starting hydraulic pressure alarm.
24. Low cranking voltage alarm.
25. Battery-charger malfunction alarm.
26. Battery low-voltage alarm.
27. Battery high-voltage alarm.
28. Generator overcurrent protective device not closed alarm.

J. 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.

K. Connection to Datalink: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication. Provide connections for datalink transmission of indications to remote data terminals via [**ModBus**] [**LonWorks**] <**Insert other data protocol**>. Data system connections to terminals are covered in Section 260913 "Electrical Power Monitoring and Control."

L. Common Remote Panel with Common Audible Alarm: Comply with NFPA 110 requirements for Level [**1**] [**2**] systems. Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine-generator set battery.

M. 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.

1. Overcrank alarm.
2. Coolant low-temperature alarm.
3. High engine temperature prealarm.
4. High engine temperature alarm.
5. Low lube oil pressure alarm.
6. Overspeed alarm.
7. Low fuel main tank alarm.
8. Low coolant level alarm.
9. Low cranking voltage alarm.

10. Contacts for local and remote common alarm.
11. Audible-alarm silencing switch.
12. Air shutdown damper when used.
13. Run-Off-Auto switch.
14. Control switch not in automatic position alarm.
15. Fuel tank derangement alarm.
16. Fuel tank high-level shutdown of fuel supply alarm.
17. Lamp test.
18. Low cranking voltage alarm.
19. Generator overcurrent protective device not closed.

N. 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.

O. 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. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.

1. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 100 percent rated; complying with UL 489.

1. Tripping Characteristic: Designed specifically for generator protection.
2. Trip Rating: Matched to generator output 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.

C. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
2. Trip Settings: Selected to coordinate with generator thermal damage curve.
3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

D. Generator Circuit Breaker: Insulated-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
2. Trip Settings: Selected to coordinate with generator thermal damage curve.

3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

E. Generator Disconnect Switch: Molded-case type, 100 percent rated.

1. Trip Rating: Matched to generator output rating.
2. Shunt Trip: Connected to trip switch when signaled by generator protector or by other protective devices.

F. 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 performs 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. Contacts shall be available for load shed functions.
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.

G. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground fault.

1. Indicate ground fault with other generator-set alarm indications.
2. Trip generator protective device on ground fault.

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. Provide [**six**] [**12**] lead alternator.

E. Range: Provide [**limited**] [**broad**] [**extended**] range of output voltage by adjusting the excitation level.

F. 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.

G. Enclosure: Dripproof.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110.

1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
2. Maintain voltage within [**15**] [**20**] [**30**] percent on one step, full load.
3. Provide anti-hunt provision to stabilize voltage.
4. Maintain frequency within [**5**] [**10**] [**15**] percent and stabilize at rated frequency within [**2**] [**5**] seconds.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

L. Subtransient Reactance: [**12**] <**Insert number**> percent, maximum.

2.10 LOAD BANK

A. Description: Permanent, outdoor, weatherproof, remote-controlled, forced-air-cooled, [**resistive**] [**resistive and reactive**] unit capable of providing a balanced three-phase, delta-connected load to generator set at [**100**] <**Insert number**> percent rated-system capacity, at [**80**] <**Insert number**> percent power factor, lagging.[**Unit may contain 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. Description: Permanent, radiator-mounted[**, resistive**] unit capable of providing a balanced three-phase, delta-connected load to generator set at [**50**] [**70**] <**Insert number**> percent rated-system capacity. Unit shall be capable of selective control of load in 25 percent steps of load bank rating and with minimum step changes of approximately 5 and 10 percent available.

C. Resistive Load Elements: Corrosion-resistant chromium alloy with ceramic and stainless-steel supports. Elements shall be double insulated and designed for repetitive on-off cycling. Elements shall be mounted in removable aluminized-steel heater cases. Galvanized steel is prohibited. Element's maximum resistance shall be between 100 and 105 percent of rated resistance.

D. Reactive Load Elements: Epoxy-encapsulated reactor coils.

E. 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.

F. Load-Element Switching: Remote-controlled contactors 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.

G. Contactor Enclosures: Heated by thermostatically controlled strip heaters to prevent condensation.

H. Load-Bank Enclosures: NEMA 250, Type 3R, aluminized steel 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- (13-mm-) square, galvanized-steel mesh. Reactive load bank shall include automatic shutters at air intake and discharge. Components other than resistive elements shall receive exterior epoxy coating with compatible primer. Comply with requirements in Section 099600 "High Performance Coatings."

I. 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.

J. 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.

K. Control Sequence: Control panel may be preset for adjustable single-step loading of generator during automatic exercising.

2.11 OUTDOOR GENERATOR-SET ENCLOSURE

A. Description: Vandal-resistant, sound-attenuating, weatherproof steel housing, wind resistant up to 100 mph (160 km/h). Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

B. Description: Prefabricated or pre-engineered galvanized-steel-clad, integral structural-steel-framed, walk-in enclosure, erected on concrete foundation.

1. Structural Design and Anchorage: Comply with ASCE 7 for wind loads up to 100 mph (160 km/h).
2. Seismic Design: Comply with seismic requirements in Section 260548.16 "Seismic Controls for Electrical Systems."
3. Fire Protection: Provide fire protection in accordance with [**Section 211316 "Dry-Pipe Sprinkler Systems."**] [**Section 211313 "Wet-Pipe Sprinkler Systems."**] Provide smoke detector in enclosure; mounted according to NFPA 72.

4. Hinged Doors: With padlocking provisions.
5. Space Heater: Thermostatically controlled and sized to prevent condensation.
6. Lighting: Provide weather resistant [**fluorescent**] [**LED**] lighting with [**30 footcandles ((330 LUX))**] [**50 footcandles ((550 LUX))**] average maintained.
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**] [**External to**] 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.
3. Ventilation: Provide temperature-controlled exhaust fan interlocked to prevent operation when engine is running.

D. Interior Lights with Switch: Factory-wired, vapor-proof 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.

2.12 MOTORS

A. Description: NEMA MG 1, Design B, medium induction random-wound, squirrel cage motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

E. 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.

F. Temperature Rise: Match insulation rating.

G. Code Letter Designation:

1. Motors [**15**] <**Insert number**> HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than [**15**] <**Insert number**> HP: Manufacturer's standard starting characteristic.

H. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

I. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

2.13 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: [**Standard neoprene**] [**Natural rubber**] [**Bridge-bearing neoprene, complying with AASHTO M 251**] separated by steel shims.
2. Shore "A" Scale Durometer Rating: [**30**] [**40**] [**45**] [**50**] [**60**] [**65**] [**70**] <**Insert number**>.
3. Number of Layers: [**One**] [**Two**] [**Three**] [**Four**] <**Insert number**>.
4. Minimum Deflection: [**1 inch (25 mm)**] <**Insert value**>.

B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Minimum Deflection: [**1 inch (25 mm)**] <**Insert value**>.

C. Comply with requirements in Section 232116 Hydronic Piping Specialties" for vibration isolation and flexible connectors materials for steel piping.

D. Comply with requirements in Section 233113 "Metal Ducts" for vibration isolation and flexible connector materials for exhaust shroud and ductwork.

E. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.14 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.15 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
2. Test generator, exciter, and voltage regulator as a unit.
3. Full load run.
4. Maximum power.
5. Voltage regulation.
6. Transient and steady-state governing.
7. Single-step load pickup.
8. Safety shutdown.
9. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
10. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.

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

3.2 PREPARATION

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 [**Architect**] [**Construction Manager**] [**Owner**] no fewer than [**two**] <**Insert number**> working days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without [**Architect's**] [**Construction Manager's**] [**Owner's**] written permission.

3.3 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**]
2. Coordinate size and location of concrete bases for packaged engine generators[**and remote radiators mounted on grade**]. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
3. Coordinate size and location of roof curbs, equipment supports, and roof penetrations for remote radiators. These items are specified in Section 077200 "Roof Accessories."

C. Install packaged engine-generator to provide access, without removing connections or accessories, for periodic maintenance.

D. Install [**packaged engine-generator**] [**engine-generator in a walk-in enclosure**] with [**elastomeric isolator pads**] [**restrained spring isolators**] having a minimum deflection of [**1 inch (25 mm)**] <**Insert static deflection**> on 4-inch- (100-mm-) high concrete base. Secure [**sets**] [**enclosure**] to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Install remote radiator with [**elastomeric isolator pads**] [**restrained spring isolators**] on [**concrete base on grade**] [**roof equipment supports on roof**].

F. Install Schedule 40, black steel piping with welded joints for cooling water piping between engine-generator set and [**heat exchanger**] [**remote radiator**]. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."

1. Install isolating thimbles where exhaust piping penetrates combustible surfaces. Provide a minimum of 9 inches (225 mm) clearance from combustibles.
2. Insulate cooling system piping and components according to requirements in Section 230719 "HVAC Piping Insulation."

G. 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.

1. Install flexible connectors and steel piping materials according to requirements in Section 232116 Hydronic Piping Specialties."
2. Insulate muffler/silencer and exhaust system components according to requirements in Section 230719 "HVAC Piping Insulation."
3. Install isolating thimbles where exhaust piping penetrates combustible surfaces with a minimum of 9 inches (225 mm) clearance from combustibles.

H. 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.

I. Installation requirements for piping materials and flexible connectors are specified in Section 232116 "Hydronic Piping Specialties." Copper and galvanized steel shall not be used in the fuel-oil piping system.

J. 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**] [**heat exchanger**] with flexible connectors.

D. Connect engine exhaust pipe to engine with flexible connector.

E. Connect fuel piping to engines with a gate valve and union and flexible connector.

1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are specified in Section 231113 "Facility Fuel-Oil Piping."
2. Natural-gas piping, valves, and specialties for gas distribution are specified in Section 231123 "Facility Natural-Gas Piping."
3. LP-gas piping, valves, and specialties for gas piping are specified in Section 231126 "Facility Liquefied-Petroleum Gas Piping."
4. Install manual shutoff valve in a remote location to isolate [**natural-gas**] [**LP-gas**] supply to the generator [**enclosure**] [**room**].
5. Vent gas pressure regulators outside building a minimum of 60 inches (1500 mm) from building openings.

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." Provide a minimum of one 90 degree bend in flexible conduit routed to the generator set from a stationary element.

H. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.5 IDENTIFICATION

A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: [**Owner will engage**] [**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.

D. Tests and Inspections:

1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in the first two subparagraphs as specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.

a. Visual and Mechanical Inspection

1) Compare equipment nameplate data with drawings and specifications.
2) Inspect physical and mechanical condition.
3) Inspect anchorage, alignment, and grounding.
4) Verify the unit is clean.

b. Electrical and Mechanical Tests

1) Perform insulation-resistance tests in accordance with IEEE 43.

a) Machines larger than 200 horsepower (150 kilowatts). Test duration shall be 10 minutes. Calculate polarization index.
b) Machines 200 horsepower (150 kilowatts) or less. Test duration shall be one minute. Calculate the dielectric-absorption ratio.

2) Test protective relay devices.
3) Verify phase rotation, phasing, and synchronized operation as required by the application.
4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
5) Conduct performance test in accordance with NFPA 110.
6) Verify correct functioning of the governor and regulator.

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 (120 kPa). 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 at 25 percent and 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**] <**Insert number**> locations [**25 feet (7.6 m) from edge of the generator enclosure**] [**on the property line**] <**Insert location for measurement**>, 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 NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

G. Leak Test: After installation, charge exhaust, coolant, and fuel systems 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 for generator and associated equipment.

I. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

J. Remove and replace malfunctioning units and [**retest**] [**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 while running with maximum load. 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 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, provide [**12**] <**Insert number**> 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.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 263213

SECTION 263353 - STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Three-phase, on-line, double-conversion, static-type, UPS units with the following features:

a. Surge suppression.
b. Input harmonics reduction.
c. Rectifier-charger.
d. Inverter.
e. Static bypass transfer switch.
f. Battery and battery disconnect device.
g. External maintenance bypass/isolation switch.
h. Output isolation transformer.
i. Remote UPS monitoring provisions.
j. Battery monitoring.
k. Remote monitoring.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. LCD: Liquid-crystal display.

C. LED: Light-emitting diode.

D. PC: Personal computer.

E. THD: Total harmonic distortion.

F. UPS: Uninterruptible power supply.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: UPS 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 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include data on features, components, ratings, and performance.

B. Shop Drawings: For UPS. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
2. Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified power quality specialist.

B. Seismic Qualification Certificates: For UPS equipment, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Manufacturer Certificates: For each product, from manufacturer.

D. Factory Test Reports: Comply with specified requirements.

E. Field quality-control reports.

F. Performance Test Reports: Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.

G. Warranties: Sample of special warranties.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For UPS units to include in emergency, operation, and maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
2. Cabinet Ventilation Filters: One complete set(s).

1.9 QUALITY ASSURANCE

A. Power Quality Specialist Qualifications: A registered professional electrical engineer or engineering technician, currently certified by the National Institute for Certification in Engineering Technologies, NICET Level 4, minimum, experienced in performance testing UPS installations and in performing power quality surveys similar to that required in "Performance Testing" Article.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. UL Compliance: Listed and labeled under UL 1778 by an NRTL.

E. NFPA Compliance: Mark UPS components as suitable for installation in computer rooms according to NFPA 75.

1.10 WARRANTY

A. Special Battery Warranties: Specified form in which manufacturer and Installer agree to repair or replace UPS system storage batteries that fail in materials or workmanship within specified warranty period.

1. Warranted Cycle Life for Valve-Regulated, Lead-Calcium Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F (25 deg C):

Discharge Rate	Discharge Duration	Discharge End Voltage	Cycle Life
8 hours	8 hours	1.67	6 cycles
30 minutes	30 minutes	1.67	20 cycles
15 minutes	45 seconds	1.67	120 cycles

B. Special UPS Warranties: Specified form in which manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within special warranty period.

1. Special Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 OPERATIONAL REQUIREMENTS

A. Automatic operation includes the following:

1. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output.
2. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to maintain constant, regulated inverter power output to the load without switching or disturbance.
3. If normal power fails, energy supplied by the battery through the inverter continues supply-regulated power to the load without switching or disturbance.
4. When power is restored at the normal supply terminals of the system, controls automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger then supplies power to the load through the inverter and simultaneously recharges the battery.
5. If the battery becomes discharged and normal supply is available, the rectifier-charger charges the battery. On reaching full charge, the rectifier-charger automatically shifts to float-charge mode.
6. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch switches the load to the normal ac supply circuit without disturbance or interruption.
7. If a fault occurs in the system supplied by the UPS, and current flows in excess of the overload rating of the UPS system, the static bypass transfer switch operates to bypass the fault current to the normal ac supply circuit for fault clearing.
8. When the fault has cleared, the static bypass transfer switch returns the load to the UPS system.
9. If the battery is disconnected, the UPS continues to supply power to the load with no degradation of its regulation of voltage and frequency of the output bus.

B. Manual operation includes the following:

1. Turning the inverter off causes the static bypass transfer switch to transfer the load directly to the normal ac supply circuit without disturbance or interruption.
2. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.

C. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless the static bypass transfer switch is in the bypass mode. Device provides manual selection among the three conditions in subparagraphs below without interrupting supply to the load during switching:

1. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS ac input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.

2. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
3. Normal: Normal UPS ac supply terminals are energized and the load is supplied through either the static bypass transfer switch and the UPS rectifier-charger and inverter, or the battery and the inverter.

D. Environmental Conditions: The UPS shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability, except battery performance.

1. Ambient Temperature for Electronic Components: 32 to 104 deg F (0 to 40 deg C).
2. Ambient Temperature for Battery: 41 to 95 deg F (5 to 35 deg C).
3. Relative Humidity: 0 to 95 percent, noncondensing.
4. Altitude: Sea level to 4000 feet (1220 m).

2.2 PERFORMANCE REQUIREMENTS

A. The UPS shall perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a load crest factor of 3.0, under the following conditions or combinations of the following conditions:

1. Inverter is switched to battery source.
2. Steady-state ac input voltage deviates up to plus or minus 10 percent from nominal voltage.
3. Steady-state input frequency deviates up to plus or minus 5 percent from nominal frequency.
4. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
5. Load is 30 percent unbalanced continuously.

B. Minimum Duration of Supply: If battery is sole energy source supplying rated full UPS load current at 80 percent power factor, duration of supply is 60 minutes.

C. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state ac input voltage varies plus 10, minus 15 percent from nominal voltage.

D. Overall UPS Efficiency: Equal to or greater than 90 percent at 100 percent load, 90 percent at 75 percent load, and 90 percent at 50 percent load.

E. Maximum Acoustical Noise: 65dBA, emanating from any UPS component under any condition of normal operation, measured 3 feet from nearest surface of component enclosure.

F. Maximum Energizing Inrush Current: Six times the full-load current.

G. Maximum AC Output-Voltage Regulation for Loads up to 50 Percent Unbalanced: Plus or minus 2 percent over the full range of battery voltage.

H. Output Frequency: 60 Hz, plus or minus 0.5 percent over the full range of input voltage, load, and battery voltage.

I. Limitation of harmonic distortion of input current to the UPS shall be as follows:

1. Description: Either a tuned harmonic filter or an arrangement of rectifier-charger circuits shall limit THD to 5 percent, maximum, at rated full UPS load current, for power sources with X/R ratio between 2 and 30.
2. Description: THD is limited to a maximum of 32 percent, at rated full UPS load current, for power sources with X/R ratio between 2 and 30.

J. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent rms total and 3 percent rms for any single harmonic, for 100 percent rated nonlinear load current with a load crest factor of 3.0.

K. Minimum Overload Capacity of UPS at Rated Voltage: 125 percent of rated full load for 10 minutes, and 150 percent for 30 seconds in all operating modes.

L. Maximum Output-Voltage Transient Excursions from Rated Value: For the following instantaneous load changes, stated as percentages of rated full UPS load, voltage shall remain within stated percentages of rated value and recover to, and remain within, plus or minus 2 percent of that value within 100 ms:

1. 50 Percent: Plus or minus 5 percent.
2. 100 Percent: Plus or minus 5 percent.
3. Loss of AC Input Power: Plus or minus 1 percent.
4. Restoration of AC Input Power: Plus or minus 1 percent.

M. Input Power Factor: A minimum of 0.9 lagging when supply voltage and current are at nominal rated values and the UPS is supplying rated full-load current.

N. EMI Emissions: Comply with FCC Rules and Regulations and with 47 CFR 15 for Class A equipment.

2.3 UPS SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following but basis of design is Eaton Powerware 9390 UPS:

1. APC by Schneider Electric.
2. Eaton Corporation.
3. Liebert; a brand of Emerson Electric Co.
4. Toshiba International Corporation.

B. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.

C. Enclosures: Comply with NEMA 250, Type 1, unless otherwise indicated.

D. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.

E. Surge Suppression: Protect internal UPS components from surges that enter at each ac power input connection including main disconnect switch, static bypass transfer switch, and maintenance bypass/isolation switch. Protect rectifier-charger, inverter, controls, and output components.

1. Use factory-installed surge suppressors tested according to IEEE C62.41.1 and IEEE C62.41.2, Category B.
2. Additional Surge Protection: Protect internal UPS components from low-frequency, high-energy voltage surges described in IEEE C62.41.1 and IEEE C62.41.2. Design the circuits connecting with external power sources and select circuit elements, conductors, conventional surge suppressors, and rectifier components and controls so input assemblies will have adequate mechanical strength and thermal and current-carrying capacity to withstand stresses imposed by 40-Hz, 180 percent voltage surges described in IEEE C62.41.1 and IEEE C62.41.2.

F. Maintainability Features: Mount rectifier-charger and inverter sections and the static bypass transfer switch on modular plug-ins, readily accessible for maintenance.

G. Capacity Upgrade Capability: Arrange wiring, controls, and modular component plug-in provisions to permit future 25 percent increase in UPS capacity.

H. Seismic-Restraint Design: UPS assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces.

I. UPS Cabinet Ventilation: Redundant fans or blowers draw in ambient air near the bottom of cabinet and discharge it near the top rear.

J. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity: Rated phase current times a multiple of 1.73, minimum.

2.4 RECTIFIER-CHARGER

A. Capacity: Adequate to supply the inverter during rated full output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.

B. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.

C. Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources.

1. Response Time: Field adjustable for maximum compatibility with local generator-set power source.

D. Battery Float-Charging Conditions: Comply with battery manufacturer's written instructions for battery terminal voltage and charging current required for maximum battery life.

2.5 INVERTER

A. Description: Pulse-width modulated, with sinusoidal output.

B. Description: Pulse-width modulated, with sinusoidal output. Include a bypass phase synchronization window adjustment to optimize compatibility with local engine-generator-set power source.

2.6 STATIC BYPASS TRANSFER SWITCH

A. Description: Solid-state switching device providing uninterrupted transfer. A contactor or electrically operated circuit breaker automatically provides electrical isolation for the switch.

B. Switch Rating: Continuous duty at the rated full UPS load current, minimum.

2.7 BATTERY

A. Description: Valve-regulated, premium, heavy-duty, recombinant, lead-calcium units; factory assembled in an isolated compartment or in a separate matching cabinet, complete with battery disconnect switch.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. C&D Technologies, Inc.
2. Eaton Corporation.
3. EnerSys.

C. Seismic-Restraint Design: Battery racks, cabinets, assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces.

2.8 CONTROLS AND INDICATIONS

A. Description: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.

B. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include audible signals and visual displays.

C. Indications: Plain-language messages on a digital LCD or LED.

1. Quantitative indications shall include the following:

a. Input voltage, each phase, line to line.
b. Input current, each phase, line to line.
c. Bypass input voltage, each phase, line to line.
d. Bypass input frequency.

e. System output voltage, each phase, line to line.
f. System output current, each phase.
g. System output frequency.
h. DC bus voltage.
i. Battery current and direction (charge/discharge).
j. Elapsed time discharging battery.

2. Basic status condition indications shall include the following:

a. Normal operation.
b. Load-on bypass.
c. Load-on battery.
d. Inverter off.
e. Alarm condition.

3. Alarm indications shall include the following:

a. Bypass ac input overvoltage or undervoltage.
b. Bypass ac input overfrequency or underfrequency.
c. Bypass ac input and inverter out of synchronization.
d. Bypass ac input wrong-phase rotation.
e. Bypass ac input single-phase condition.
f. Bypass ac input filter fuse blown.
g. Internal frequency standard in use.
h. Battery system alarm.
i. Control power failure.
j. Fan failure.
k. UPS overload.
l. Battery-charging control faulty.
m. Input overvoltage or undervoltage.
n. Input transformer overtemperature.
o. Input circuit breaker tripped.
p. Input wrong-phase rotation.
q. Input single-phase condition.
r. Approaching end of battery operation.
s. Battery undervoltage shutdown.
t. Maximum battery voltage.
u. Inverter fuse blown.
v. Inverter transformer overtemperature.
w. Inverter overtemperature.
x. Static bypass transfer switch overtemperature.
y. Inverter power supply fault.
z. Inverter transistors out of saturation.
aa. Identification of faulty inverter section/leg.
bb. Inverter output overvoltage or undervoltage.
cc. UPS overload shutdown.
dd. Inverter current sensor fault.
ee. Inverter output contactor open.
ff. Inverter current limit.

4. Controls shall include the following:

a. Inverter on-off.
b. UPS start.
c. Battery test.
d. Alarm silence/reset.
e. Output-voltage adjustment.

D. Dry-form "C" contacts shall be available for remote indication of the following conditions:

1. UPS on battery.
2. UPS on-line.
3. UPS load-on bypass.
4. UPS in alarm condition.
5. UPS off (maintenance bypass closed).

E. Emergency Power Off Switch: Capable of local operation and operation by means of activation by external dry contacts.

2.9 MAINTENANCE BYPASS/ISOLATION SWITCH

A. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.

1. Switch shall be electrically and mechanically interlocked to prevent interrupting power to the load when switching to bypass mode.
2. Switch shall electrically isolate other UPS components to permit safe servicing.

B. Comply with NEMA PB 2 and UL 891.

C. Switch Rating: Continuous duty at rated full UPS load current.

D. Mounting Provisions: Separate wall- or floor-mounted unit.

E. Key interlock requires unlocking maintenance bypass/isolation switch before switching from normal position with key that is released only when the UPS is bypassed by the static bypass transfer switch. Lock is designed specifically for mechanical and electrical component interlocking.

2.10 OUTPUT ISOLATION TRANSFORMER

A. Description: Shielded unit with low forward transfer impedance up to 3 kHz, minimum. Include the following features:

1. Comply with applicable portions of UL 1561, including requirements for nonlinear load current-handling capability for a K-factor of approximately 13.
2. Output Impedance at Fundamental Frequency: Between 3 and 4 percent.
3. Regulation: 5 percent, maximum, at rated nonlinear load current.
4. Full-Load Efficiency at Rated Nonlinear Load Current: 96 percent, minimum.
5. Electrostatic Shielding of Windings: Independent for each winding.

6. Coil Leads: Physically arranged for minimum interlead capacitance.
7. Shield Grounding Terminal: Separately mounted; labeled "Shield Ground."
8. Capacitive Coupling between Primary and Secondary: 33 picofarads, maximum, over a frequency range of 20 Hz to 1 MHz.

2.11 OUTPUT DISTRIBUTION SECTION

A. Panelboards: Comply with Section 262416 "Panelboards" except provide assembly integral to UPS cabinet.

2.12 MONITORING BY REMOTE STATUS AND ALARM PANEL

A. Description: Labeled LEDs on panel faceplate indicate five basic status conditions. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication.

1. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.

2.13 MONITORING BY REMOTE COMPUTER

A. Description: Communication module in unit control panel provides capability for remote monitoring of status, parameters, and alarms specified in "Controls and Indications" Article. The remote computer and the connecting signal wiring are not included in this Section. Include the following features:

1. Connectors and network interface units or modems for data transmission via RS-232 link.
2. Software designed for control and monitoring of UPS functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of meaningful reports. Permit storage and analysis of power-line transient records. Designs for Windows applications, software, and computer are not included in this Section.
3. Software and Hardware: Compatible with that specified in Section 260913 "Electrical Power Monitoring and Control."

2.14 BASIC BATTERY MONITORING

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Alber.
2. BTECH, Inc.
3. Eaton Corporation.

B. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.

C. Battery compartment smoke/high-temperature detector initiates an alarm when smoke or a temperature greater than 75 deg C occurs within the compartment.

D. Annunciation of Alarms: At UPS control panel.

2.15 BATTERY-CYCLE WARRANTY MONITORING

A. Description: Electronic device, acceptable to battery manufacturer as a basis for warranty action, for monitoring of charge-discharge cycle history of batteries covered by cycle-life warranties.

B. Performance: Automatically measures and records each discharge event, classifies it according to duration category, and totals discharges according to warranty criteria, displaying remaining warranted battery life on front panel display.

C. Additional monitoring functions and features shall include the following:

1. Measuring and Recording: Total voltage at battery terminals; initiates alarm for excursions outside the proper float-voltage level.
2. Monitors: Ambient temperature at battery; initiates alarm if temperature deviates from normally acceptable range.
3. Keypad on Device Front Panel: Provides access to monitored data using front panel display.
4. Alarm Contacts: Arranged to initiate remote alarm for battery discharge events and abnormal battery voltage or temperature.
5. Memory: Stores recorded data in nonvolatile electronic memory.
6. RS-232 Port: Permits downloading of data to a portable PC.
7. Modem: Makes measurements and recorded data accessible to a remote PC via telephone line. Computer is not specified in this Section.

2.16 SOURCE QUALITY CONTROL

A. Factory test complete UPS system before shipment. Use actual batteries that are part of final installation. Include the following:

1. Test and demonstration of all functions, controls, indicators, sensors, and protective devices.
2. Full-load test.
3. Transient-load response test.
4. Overload test.
5. Power failure test.

B. Observation of Test: Give 14 days' advance notice of tests and provide opportunity for Owner's representative to observe tests at Owner's choice.

C. Report test results. Include the following data:

1. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.

2. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
3. List of instruments and equipment used in factory tests.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for conditions affecting performance of the UPS.

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

3.2 INSTALLATION

A. Equipment Mounting: Install UPS on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of 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 supported equipment.

B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

C. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams unless otherwise indicated.

3.3 GROUNDING

A. Separately Derived Systems: If not part of a listed power supply for a data-processing room, comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer.

3.4 IDENTIFICATION

A. Identify components and wiring according to Section 260553 "Identification for Electrical Systems."

3.5 BATTERY EQUALIZATION

A. Equalize charging of battery cells according to manufacturer's written instructions. Record individual-cell voltages.

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. Comply with manufacturer's written instructions.
2. Inspect interiors of enclosures, including the following:

    a. Integrity of mechanical and electrical connections.
    b. Component type and labeling verification.
    c. Ratings of installed components.

3. Inspect batteries and chargers according to requirements in NETA Acceptance Testing Specifications.
4. Test manual and automatic operational features and system protective and alarm functions.
5. Test communication of status and alarms to remote monitoring equipment.
6. Load the system using a variable-load bank to simulate kilovolt amperes, kilowatts, and power factor of loads for unit's rating. Use instruments calibrated within the previous six months according to NIST standards.

    a. Simulate malfunctions to verify protective device operation.
    b. Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.
    c. Test harmonic content of input and output current less than 25, 50, and 100 percent of rated loads.
    d. Test output voltage under specified transient-load conditions.
    e. Test efficiency at 50, 75, and 100 percent of rated loads.
    f. Test remote status and alarm panel functions.
    g. Test battery-monitoring system functions.

E. Seismic-restraint tests and inspections shall include the following:

1. Inspect type, size, quantity, arrangement, and proper installation of mounting or anchorage devices.

2. Test mounting and anchorage devices according to requirements in Section 260548.16 "Seismic Controls for Electrical Systems."

F. The UPS system will be considered defective if it does not pass tests and inspections.

G. Record of Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of tests, inspections, and retests.

H. Prepare test and inspection reports.

3.7 PERFORMANCE TESTING

A. Engage the services of a qualified power quality specialist to perform tests and activities indicated.

B. Monitoring and Testing Schedule: Perform monitoring and testing in a single 10-day period.

1. Schedule monitoring and testing activity with Owner, through Architect, with at least 14 days' advance notice.
2. Schedule monitoring and testing after Substantial Completion, when the UPS is supplying power to its intended load.

C. Monitoring and Testing Instruments: Three-phase, recording, power monitors. Instruments shall provide continuous simultaneous monitoring of electrical parameters at UPS input terminals and at input terminals of loads served by the UPS. Instruments shall monitor, measure, and graph voltage current and frequency simultaneously and provide full-graphic recordings of the values of those parameters before and during power-line disturbances that cause the values to deviate from normal beyond the adjustable threshold values. Instruments shall be capable of recording either on paper or on magnetic media and have a minimum accuracy of plus or minus 2 percent for electrical parameters. Parameters to be monitored include the following:

1. Current: Each phase and neutral and grounding conductors.
2. Voltage: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
3. Frequency transients.
4. Voltage swells and sags.
5. Voltage Impulses: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
6. High-frequency noise.
7. Radio-frequency interference.
8. THD of the above currents and voltages.
9. Harmonic content of currents and voltages above.

D. Monitoring and Testing Procedures:

1. Exploratory Period: For the first two days of the first scheduled monitoring and testing period, make recordings at various circuit locations and with various parameter-threshold and sampling-interval settings. Make these measurements with the objective of identifying optimum UPS, power system, load, and instrumentation setup conditions for subsequent test and monitoring operations.

2. Remainder of Test Period: Perform continuous monitoring of at least two circuit locations selected on the basis of data obtained during exploratory period.

    a. Set thresholds and sampling intervals for recording data at values selected to optimize data on performance of the UPS for values indicated, and to highlight the need to adjust, repair, or modify the UPS, distribution system, or load component that may influence its performance or that may require better power quality.
    b. Perform load and UPS power source switching and operate the UPS on generator power during portions of test period according to directions of Owner's power quality specialist.
    c. Operate the UPS and its loads in each mode of operation permitted by UPS controls and by the power distribution system design.
    d. Using loads and devices available as part of the facility's installed systems and equipment, create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients. Maintain normal operating loads in operation on system to maximum extent possible during tests.
    e. Using temporarily connected resistive/inductive load banks, create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients. Maintain normal operating loads in operation on system to maximum extent possible during tests.
    f. Make adjustments and repairs to UPS, distribution, and load equipment to correct deficiencies disclosed by monitoring and testing and repeat appropriate monitoring and testing to verify success of corrective action.

E. Coordination with Specified UPS Monitoring Functions: Obtain printouts of built-in monitoring functions specified for the UPS and its components in this Section that are simultaneously recorded with portable instruments in this article.

1. Provide the temporary use of an appropriate PC and printer equipped with required connections and software for recording and printing if such units are not available on-site.
2. Coordinate printouts with recordings for monitoring performed according to this article, and resolve and report any anomalies in and discrepancies between the two sets of records.

F. Monitoring and Testing Assistance by Contractor:

1. Open UPS and electrical distribution and load equipment and wiring enclosures to make monitoring and testing points accessible for temporary monitoring probe and sensor placement and removal as requested.
2. Observe monitoring and testing operations; ensure that UPS and distribution and load equipment warranties are not compromised.
3. Perform switching and control of various UPS units, electrical distribution systems, and load components as directed by power quality specialist. Specialist shall design this portion of monitoring and testing operations to expose the UPS to various operating environments, conditions, and events while response is observed, electrical parameters are monitored, and system and equipment deficiencies are identified.
4. Make repairs and adjustments to the UPS and to electrical distribution system and load components, and retest and repeat monitoring as needed to verify validity of results and correction of deficiencies.

5. Engage the services of the UPS manufacturer's factory-authorized service representative periodically during performance testing operations for repairs, adjustments, and consultations.

G. Documentation: Record test point and sensor locations, instrument settings, and circuit and load conditions for each monitoring summary and power disturbance recording. Coordinate simultaneous recordings made on UPS input and load circuits.

H. Analysis of Recorded Data and Report: Review and analyze test observations and recorded data and submit a detailed written report. Include the following inreport:

1. Description of corrective actions performed during monitoring and survey work and their results.
2. Recommendations for further action to provide optimum performance by the UPS and appropriate power quality for non-UPS loads. Include a statement of priority ranking and a cost estimate for each recommendation that involves system or equipment revisions.
3. Copies of monitoring summary graphics and graphics illustrating harmonic content of significant voltages and currents.
4. Copies of graphics of power disturbance recordings that illustrate findings, conclusions, and recommendations.
5. Recommendations for operating, adjusting, or revising UPS controls.
6. Recommendation for alterations to the UPS installation.
7. Recommendations for adjusting or revising generator-set or automatic transfer switch installations or their controls.
8. Recommendations for power distribution system revisions.
9. Recommendations for adjusting or revising electrical loads, their connections, or controls.

I. Interim and Final Reports: Provide an interim report at the end of each test period and a final comprehensive report at the end of final test and analysis period.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the UPS.

END OF SECTION 263353

SECTION 263600 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes transfer switches rated 600 V and less, including the following:

1. Automatic transfer switches.
2. Bypass/isolation switches.
3. Remote annunciation and control systems.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

1. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer.

B. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Section 260548.16 "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."
b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Features and operating sequences, both automatic and manual.
2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain automatic transfer switches 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, by a qualified testing agency, and marked for intended location and application.

E. Comply with NEMA ICS 1.

F. Comply with NFPA 70.

G. Comply with NFPA 99.

H. Comply with NFPA 110.

I. Comply with UL 1008 unless requirements of these Specifications are stricter.

1.7 FIELD CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service:

1. Notify Construction Manager no fewer than thirty days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Owner's written permission.

1.8 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 033000 "Cast-in-Place Concrete."

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Contactor Transfer Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton.
b. GE Zenith Controls.
c. General Electric Company.
d. Onan/Cummins Power Generation.
e. Russelectric, Inc.

B. Transfer Switches Using Molded-Case Switches or Circuit Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton.
b. GE Zenith Controls.
c. Onan/Cummins Power Generation; Industrial Business Group.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.

C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

E. Electrical Operation: Accomplish by a non-fused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.

G. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.

H. Oversize Neutral: Ampacity 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.

I. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.

J. 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.

K. 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.

L. Enclosures: General-purpose NEMA 250, Type 4, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.3 AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

D. 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.

E. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

F. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.

G. 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.

H. 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.

I. 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.

J. 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.

K. Automatic Transfer-Switch Features:

1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30

minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
b. Push-button programming control with digital display of settings.
c. Integral battery operation of time switch when normal control power is not available.

2.4 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 SOURCE QUALITY CONTROL

A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Section 260548.16 "Seismic Controls for Electrical Systems."

B. Floor-Mounting Switch: Anchor to floor by bolting.

1. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) 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."

C. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.

D. Identify components according to Section 260553 "Identification for Electrical Systems."

E. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and

procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

a. Check for electrical continuity of circuits and for short circuits.
b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
c. Verify that manual transfer warnings are properly placed.
d. Perform manual transfer operation.

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.
2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

a. Check for electrical continuity of circuits and for short circuits.
b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
c. Verify that manual transfer warnings are properly placed.
d. Perform manual transfer operation.

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.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Refer to Section 017900 "Demonstration and Training."

B. Coordinate this training with that for generator equipment.

END OF SECTION

SECTION 265119 - LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Interior solid-state luminaires that use LED technology.
2. Lighting fixture supports.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Section 260943.16 "Addressable-Fixture Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls" for manual or programmable control systems with low-voltage control wiring or data communication circuits.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Arrange in order of luminaire designation.

2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include emergency lighting units, including batteries and chargers.
5. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
6. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing and Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps and accessories identical to those indicated for the lighting fixture as applied in this Project IES LM-79 and IES LM-80.

    a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
    b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. LEED Submittals:

D. Samples: For each luminaire and for each color and texture with standard factory-applied finish.

E. Samples for Initial Selection: For each type of luminaire with custom factory-applied finishes.

1. Include Samples of luminaires and accessories involving color and finish selection.

F. Samples for Verification: For each type of luminaire.

1. Include Samples of luminaires and accessories to verify finish selection.

G. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Lighting luminaires.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches (300 mm) of the plane of the luminaires.
4. Structural members to which equipment and or luminaires will be attached.
5. Initial access modules for acoustical tile, including size and locations.

6. Items penetrating finished ceiling, including the following:

    a. Other luminaires.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Ceiling-mounted projectors.

7. Moldings.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Seismic Qualification Certificates: For luminaires, 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.

D. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Product Certificates: For each type of luminaire.

F. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

G. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
2. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

C. Provide luminaires from a single manufacturer for each luminaire type.

D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

E. Mockups: For interior lighting luminaires in room or module mockups, complete with power and control connections.

1. Obtain Architect's approval of luminaires in mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 LUMINAIRE REQUIREMENTS

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. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. Recessed Fixtures: Comply with NEMA LE 4.

E. Bulb shape complying with ANSI C79.1.

F. Lamp base complying with ANSI C81.61 or IEC 60061-1.

G. CRI of minimum 80. CCT of 4100 K or as indicated in the light fixtures schedule.

H. Rated lamp life of 50,000 hours.

I. Lamps dimmable from 100 percent to 0 percent of maximum light output.

J. Internal driver.

K. Nominal Operating Voltage: 277 V ac.

1. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

L. Housings:

1. Extruded-aluminum housing and heat sink.
2. Clear anodized finish, unless otherwise noted in lighting fixtures schedule.

M. Meet CEC Title 24 Luminaire efficacy.

N. Refer to drawings for lighting fixture schedule basis of design.

2.3 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:
1. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

D. Housings:

1. Extruded-aluminum housing and heat sink.
2. Clear anodized finish.

E. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.
b. Lamp diameter, shape, size, wattage, and coating.
c. CCT and CRI for all luminaires.

2.4 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.5 LUMINAIRE FIXTURE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

D. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

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 luminaire to verify actual locations of luminaire and electrical connections before fixture installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaire Support:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

G. Ceiling-Mounted Luminaire Support:

1. Ceiling mount with two 5/32-inch- (4-mm-) diameter aircraft cable supports adjustable to 120 inches (6 m) in length.

2. Ceiling mount with hook mount.

H. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

I. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

J. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Comply with requirements for startup specified in Section 260943.16 "Addressable-Fixture Lighting Controls."

B. Comply with requirements for startup specified in Section 260943.23 "Relay-Based Lighting Controls."

3.7 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 265119

SECTION 265219 - EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Emergency lighting units.
2. Exit signs.
3. Luminaire supports.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.

D. Fixture: See "Luminaire" Paragraph.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support.

1. Include data on features, accessories, and finishes.
2. Include physical description of the unit and dimensions.
3. Battery and charger for light units.
4. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
5. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.

a. Testing Agency Certified Data: For indicated luminaires and signs, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires and signs shall be certified by manufacturer.
b. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Samples: For each product and for each color and texture specified.

D. Samples for Initial Selection: For each type of luminaire with factory-applied finishes.

E. Samples for Verification: For each type of luminaire.

1. Include Samples of luminaires and accessories to verify finish selection.

F. Product Schedule:

1. For emergency lighting units. Use same designations indicated on Drawings.
2. For exit signs. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Luminaires.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches (300 mm) of the plane of the luminaires.
4. Structural members to which equipment will be attached.
5. Size and location of initial access modules for acoustical tile.
6. Items penetrating finished ceiling including the following:

a. Other luminaires.
b. Air outlets and inlets.
c. Speakers.
d. Ceiling-mounted projectors.
e. Sprinklers.
f. Access panels.

7. Moldings.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Product Certificates: For each type of luminaire.

D. Seismic Qualification Certificates: For luminaires, 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.

E. Product Test Reports: For each luminaire for tests performed by manufacturer and witnessed by a qualified testing agency.

F. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, operation, and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
2. Luminaire-mounted, emergency battery pack: One for every 20 emergency lighting units. Furnish at least one of each type.
3. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as

defined by OSHA in 29 CFR 1910.7, accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. Mockups: For interior luminaires in room or module mockups, complete with power and control connections.

1. Obtain Architect's approval of luminaires and signs in mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two year(s) from date of Substantial Completion.

B. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Emergency Power Unit Batteries: 5 years from date of Substantial Completion. Full warranty shall apply for first year and prorated warranty for the remaining four years.
2. Warranty Period for Self-Powered Exit Sign Batteries: Seven years from date of Substantial Completion. Full warranty shall apply for first year and prorated warranty for the remaining six years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

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. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.

C. Comply with NFPA 70 and NFPA 101.

D. Comply with NEMA LE 4 for recessed luminaires.

E. Comply with UL 1598 for fluorescent luminaires.

F. Lamp Base: Comply with ANSI C81.61 or IEC 60061-1.

G. Bulb Shape: Complying with ANSI C79.1.

H. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body.

1. Emergency Connection: Operate one lamp(s) continuously at an output of 1100 lumens each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.
2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
3. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Less than 0 deg F (minus 18 deg C) or exceeding 104 deg F (40 deg C), with an average value exceeding 95 deg F (35 deg C) over a 24-hour period.
    b. Ambient Storage Temperature: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C).
    c. Humidity: More than 95 percent (condensing).

d. Altitude: Exceeding 3300 feet (1000 m).

4. Nightlight Connection: Operate lamp continuously at 40 percent of rated light output.
5. Test Push-Button and Indicator Light: Visible and accessible without opening luminaire or entering ceiling space.

   a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
   b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

6. Battery: Sealed, maintenance-free, nickel-cadmium type.
7. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
8. Remote Test: Switch in handheld remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

I. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more lamps, remote mounted from luminaire.

1. Emergency Connection: Operate one LED lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire.
2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
3. Nightlight Connection: Operate lamp in a remote luminaire continuously.
4. Battery: Sealed, maintenance-free, nickel-cadmium type.
5. Charger: Fully automatic, solid-state, constant-current type.
6. Housing: NEMA 250, Type 1 enclosure listed for installation inside, on top of, or remote from luminaire. Remote assembly shall be located no less than half the distance recommended by the emergency power unit manufacturer, whichever is less.
7. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
8. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
9. Remote Test: Switch in handheld remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
10. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.3 EMERGENCY LIGHTING

A. General Requirements for Emergency Lighting Units: Self-contained units.

B. Emergency Luminaires:
1. Refer to drawings for lighting fixture schedule basis of design.

2.4 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Cooper Lighting, an Eaton business.
    b. Hubbell Industrial Lighting; Hubbell Incorporated.
    c. Lithonia Lighting; Acuity Brands Lighting, Inc.
    d. Philips Lighting Company.

2. Operating at nominal voltage of 277 V ac.
3. Lamps for AC Operation: Fluorescent, two for each luminaire; 20,000 hours of rated lamp life.
4. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
5. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.
6. Master/Remote Sign Configurations:

    a. Master Unit: Comply with requirements above for self-powered exit signs, and provide additional capacity in LED power supply for power connection to remote unit.
    b. Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery, and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.

2.5 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access:

1. Smooth operating, free of light leakage under operating conditions.
2. Designed to permit relamping without use of tools.

3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:
1. Glass: Annealed crystal glass unless otherwise indicated.
2. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

D. Housings:

1. Extruded aluminum housing and heat sink.
2. Clear anodized finish.

E. Conduit: Electrical metallic tubing, minimum 3/4 inch (21 mm) in diameter.

2.6 METAL FINISHES

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.7 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Support Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.

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

3.2 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire and emergency power unit weight.
2. Able to maintain luminaire position when testing emergency power unit.
3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of luminaire weight.

E. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

F. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

G. Ceiling Grid Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure emergency power unit using approved fasteners in a minimum of four locations, spaced near corners of emergency power unit.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Perform startup service:

1. Charge batteries minimum of one hour and depress switch to conduct short-duration test.
2. Charge batteries minimum of 24 hours and conduct one-hour discharge test.

3.6 ADJUSTING

A. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:

1. Inspect all luminaires. Replace lamps, batteries, signs, or luminaires that are defective.

a. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

2. Conduct short-duration tests on all emergency lighting.

END OF SECTION 265219

SECTION 265613 - LIGHTING POLES AND STANDARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Poles and accessories for support of luminaires.
2. Luminaire-lowering devices.

1.3 DEFINITIONS

A. EPA: Equivalent projected area.

B. Luminaire: Complete lighting fixture.

C. Pole: Luminaire-supporting structure, including tower used for large-area illumination.

D. Standard: See "Pole."

1.4 ACTION SUBMITTALS

A. Product Data: For each pole, accessory, and luminaire-supporting and -lowering device, arranged as indicated.

1. Include data on construction details, profiles, EPA, cable entrances, materials, dimensions, weight, rated design load, and ultimate strength of individual components.
2. Include finishes for lighting poles and luminaire-supporting devices.
3. Anchor bolts.
4. Manufactured pole foundations.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of poles and pole accessories.

4. Foundation construction details, including material descriptions, dimensions, anchor bolts, support devices, and calculations, signed and sealed by a professional engineer licensed in the state of installation.
5. Anchor bolt templates keyed to specific poles and certified by manufacturer.
6. Method and procedure of pole installation. Include manufacturer's written installations.

C. Samples: For each exposed lighting pole, standard, and luminaire-supporting device and for each color and texture specified.

1.5 INFORMATIONAL SUBMITTALS

A. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements according to AASHTO LTS-6-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations signed and sealed by a professional engineer.

B. Qualification Data: For Installer and testing agency.

C. Seismic Qualification Certificates: For lights, 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.

D. Material Test Reports:

1. For each foundation component, by a qualified testing agency.
2. For each pole, by a qualified testing agency.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample Warranty: Manufacturer's standard warranty.

H. Soil test reports

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For poles to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include pole inspection and repair procedures.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Pole repair materials.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM C 1093 for foundation testing.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B 660.

B. Store poles on decay-resistant skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch (6 mm) deep. Do not apply tools to section of pole to be installed below finished grade.

D. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.

E. Retain factory-applied pole wrappings on metal poles until right before pole installation. Handle poles with web fabric straps.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of pole(s) that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within a specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs from special warranty period.

1. Warranty Period: Five years from date of Substantial Completion.
2. Warranty Period for Corrosion Resistance: Five years from date of Substantial Completion.
3. Warranty Period for Color Retention: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design pole foundation and pole power system.

B. Seismic Performance: Foundation and pole shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."
2. Component Importance Factor: 1.0.

C. Structural Characteristics: Comply with AASHTO LTS-6-M.

D. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied according to AASHTO LTS-6-M.

E. Live Load: Single load of 500 lbf (2200 N) distributed according to AASHTO LTS-6-M.

F. Ice Load: Load of 3 lbf/sq. ft. (145 Pa), applied according to AASHTO LTS-6-M for applicable areas on the Ice Load Map.

G. Wind Load: Pressure of wind on pole and luminaire, calculated and applied according to AASHTO LTS-6-M.

1. Basic wind speed for calculating wind load for poles 50 feet (15 m) high or less is 90 mph (40 m/s).

a. Wind Importance Factor: 1.0.
b. Minimum Design Life: 25 years.
c. Velocity Conversion Factor: 1.0.

H. Strength Analysis: For each pole, multiply the actual EPA of luminaires and brackets by a factor of 1.1 to obtain the EPA to be used in pole selection strength analysis.

I. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

2.2 STEEL POLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper Lighting, an Eaton business.
2. EGS/Appleton Electric.
3. Hubbell Incorporated.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. LSI Corporation of America.

B. Source Limitations: Obtain poles from single manufacturer or producer.

C. Source Limitations: For poles, obtain each color, grade, finish, type, and variety of pole from single source with resources to provide products of consistent quality in appearance and physical properties.

D. Poles: Comply with ASTM A 500/A 500M, Grade B carbon steel with a minimum yield of 46,000 psig (317 MPa); one-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.

1. Shape: Square, straight.
2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

E. Poles: Comply with ASTM A 240/A 240M, stainless steel with a minimum yield of 55,000 psig (379 MPa); one-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.

1. Shape: Square, straight.
2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

F. Steel Mast Arms: Single-arm type, continuously welded to pole attachment plate. Material and finish same as plate.

G. Brackets for Luminaires: Detachable, cantilever, without underbrace.

1. Adaptor fitting welded to pole, allowing the bracket to be bolted to the pole-mounted adapter, then bolted together with galvanized-steel bolts.
2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match pole material and finish.

H. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

I. Fasteners: Galvanized steel, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.

1. Materials: Compatible with poles and standards as well as the substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.
2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

J. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size indicated, and accessible through handhole.

K. Steps: Fixed steel, with nonslip treads.

1. For climbing positions, install at 15-inch (381-mm) vertical spacing, alternating on opposite sides of pole, oriented 180 degrees from each other; first step shall be at an elevation 10 feet (3 m) above finished grade.
2. For working positions, install steps on opposite side of pole, oriented 180 degrees from each other at the same elevation.

L. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws.

M. Intermediate Handhole and Cable Support: Weatherproof, 3-by-5-inch (76-by-130-mm) handhole located at midpoint of pole, with cover for access to internal welded attachment lug for electric cable support grip.

N. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported load multiplied by a 5.0 safety factor.

O. Platform for Lamp and Ballast Servicing: Factory fabricated of steel, with finish matching that of pole.

P. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

Q. Galvanized Finish: After fabrication, hot-dip galvanize according to ASTM A 123/A 123M.

R. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces according to SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high gloss, high-build polyurethane enamel.

    a. Color: As selected by Architect from manufacturer's full range.

S. Powder-Coat Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces according to SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair powder coat bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Powder Coat: Comply with AAMA 2604.

    a. Electrostatic-applied powder coating; single application and cured to a minimum 2.5- to 3.5-mils dry film thickness. Coat interior and exterior of pole for equal corrosion protection.
    b. Color: As selected by Architect from manufacturer's full range.

2.3 POLE ACCESSORIES

A. Duplex Receptacle: Ground-fault circuit interrupter type, 120 V ac, 20 A in a weatherproof assembly. Comply with requirements in Section 262726 "Wiring Devices."

1. Recessed 12 inches (300 mm) above finished grade.

    a. NEMA 250, Type 4X, nonmetallic polycarbonate plastic or reinforced fiberglass, enclosure with cover; color to match pole.
    b. Lockable hasp and latch complying with OSHA lockout and tag-out requirements.

B. Minimum 1800-W transformer, protected by replaceable fuses, mounted behind access cover.

C. Base Covers: Manufacturers' standard metal units, finished same as pole, and arranged to cover pole's mounting bolts and nuts.

D. Transformer-Type Base: Same material and color as pole. Coordinate dimensions to suit pole's base flange and to accept indicated accessories. Include removable flanged access cover secured with bolts or screws.

2.4 MOUNTING HARDWARE

A. Anchor Bolts: Manufactured to ASTM F 1554, Grade 55, with a minimum yield strength of 55,000 psi (380,000 kPa).

1. Galvanizing: Hot dip galvanized according to ASTM A 153, Class C.
2. Threading: Uniform National Coarse, Class 2A.

B. Nuts: ASTM A 563, Grade A, Heavy-Hex

1. Galvanizing: Hot dip galvanized according to ASTM A 153, Class C.
2. Four nuts provided per anchor bolt, shipped with nuts pre-assembled to the anchor bolts.

C. Washers: ASTM F 436, Type 1.

1. Galvanizing: Hot dip galvanized according to ASTM A 153, Class C.
2. Two washers provided per anchor bolt.

2.5 GENERAL FINISH REQUIREMENTS

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine poles, luminaire-mounting devices, lowering devices, and pole accessories before installation. Components that are scratched, dented, marred, wet, moisture damaged, or visibly damaged are considered defective.

C. Examine roughing-in for foundation and conduit to verify actual locations of installation.

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

3.2 POLE FOUNDATION

A. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123 M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

B. Pre-Cast Foundations: Factory fabricated, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

C. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories.

1. Baseplate: Stamped with manufacturer's name, date of production, and cable entry.

D. Direct-Buried Foundations: Install to depth indicated on Drawings, but not less than as indicated. Add backfill in 6-inch (150-mm) to 9-inch (230-mm) layers, tamping each layer before adding the next. To ensure a plumb installation, continuously check pole orientation with plumb bob while tamping.

E. Direct-Buried Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than as indicated. To ensure a plumb installation, continuously check pole orientation with plumb bob while tamping.

1. Make holes 6 inches (150 mm) in diameter larger than pole diameter.
2. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi (20 MPa) at 28 days and finish in a dome above finished grade.
3. Use a short piece of 1/2-inch (13-mm) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
4. Cure concrete a minimum of 72 hours before performing work on pole.

F. Anchor Bolts: Install plumb using manufacturer-supplied steel template, uniformly spaced.

3.3 POLE INSTALLATION

A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on drawing.

1. Fire Hydrants and Water Piping: 60 inches (1520 mm).
2. Water, Gas, Electric, Communications, and Sewer Lines: 10 feet (3 m).
3. Trees: 15 feet (5 m) from tree trunk.

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Section 033000 "Cast-in-Place Concrete."

D. Foundation-Mounted Poles: Mount pole with leveling nuts and tighten top nuts to torque level according to pole manufacturer's written instructions.

1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
3. Install base covers unless otherwise indicated.
4. Use a short piece of 1/2 -inch (13-mm) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Poles and Pole Foundations Set in Concrete-Paved Areas: Install poles with a minimum 6-inch- (150-mm-) wide, unpaved gap between the pole or pole foundation and the edge of the adjacent concrete slab. Fill unpaved ring with pea gravel. Insert material to a level 1 inch (25 mm) below top of concrete slab.

F. Raise and set pole using web fabric slings (not chain or cable) at locations indicated by manufacturer.

3.4 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum using insulating fittings or treatment.

B. Steel Conduits: Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50-percent overlap.

3.5 GROUNDING

A. Ground Metal Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole unless otherwise indicated.
2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

B. Ground Nonmetallic Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole.
2. Install grounding conductor and conductor protector.
3. Ground metallic components of pole accessories and foundation.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:

1. Inspect poles for nicks, mars, dents, scratches, and other damage.
2. System function tests.

END OF SECTION 265613

SECTION 265619 – LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
2. Luminaire supports.
3. Luminaire-mounted photoelectric relays.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Section 260926 "Lighting Control Panelboards" for panelboard-based lighting control.
3. Section 260943.16 "Addressable-Fixture Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls" for manual or programmable control systems with low-voltage control wiring or data communication circuits.
4. Section 265613 "Lighting Poles and Standards" for poles and standards used to support exterior lighting equipment.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color rendering index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of luminaire.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaire.
4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.
5. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project, IES LM-79 and IES LM-80.

    a. Manufacturer's Certified Data: Photometric data certified by manufacturer?s laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.
    b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

6. Wiring diagrams for power, control, and signal wiring.
7. Photoelectric relays.
8. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. LEED Submittals:

1. Product Data for Credit EA 5: For specified metering equipment.
2. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.

D. Samples: For each luminaire and for each color and texture indicated with factory-applied finish.

E. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

F. Delegated-Design Submittal: For luminaire supports.

1. Include design calculations for luminaire supports and seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Luminaires.
2. Structural members to which equipment and luminaires will be attached.
3. Underground utilities and structures.
4. Existing underground utilities and structures.
5. Above-grade utilities and structures.
6. Existing above-grade utilities and structures.
7. Building features.
8. Vertical and horizontal information.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Seismic Qualification Certificates: For luminaires, 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.

D. Product Certificates: For each type of the following:

1. Luminaire.
2. Photoelectric relay.

E. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

F. Source quality-control reports.

G. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.
2. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
2. Glass, Acrylic, and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Diffusers and Lenses: One for every 100of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products and complying with applicable IES testing standards.

C. Provide luminaires from a single manufacturer for each luminaire type.

D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

E. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

F. Mockups: For exterior luminaires, complete with power and control connections.

1. Obtain Architect's approval of luminaires in mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.10 FIELD CONDITIONS

A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.

B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.11 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures, including luminaire support components.
b. Faulty operation of luminaires and accessories.
c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Period: 2 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 LUMINAIRE REQUIREMENTS

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. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. UL Compliance: Comply with UL 1598 and listed for wet location.

E. Lamp base complying with ANSI C81.61 or IEC 60061-1.

F. Bulb shape complying with ANSI C79.1.

G. CRI of minimum 80. CCT of 4100 K.

H. L70 lamp life of 50,000 hours.

I. Lamps dimmable from 100 percent to 0 percent of maximum light output.

J. Internal driver.

K. Nominal Operating Voltage: 277 V ac.

L. In-line Fusing: On the primary for each luminaire.

M. Lamp Rating: Lamp marked for outdoor use.

N. Source Limitations: Obtain luminaires from single source from a single manufacturer.

O. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.3 LUMINAIRE TYPES

A. Area and Site:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Luminaire Shape: [**Round**] [**Square**] [**Hexagonal**] <**Insert shape or feature**>.
3. Mounting: [**Pole**] [**Building**] <**Insert mounting type**> with [**extruded-aluminum**] [**stainless-steel**] <**Insert material**> [**rectangular**] [**round**] arm, [**11 inches (280 mm)**][**13 inches (330 mm)**]in length.
4. Luminaire-Mounting Height: <**Insert height of luminaire from finished grade**>.
5. Distribution: [**Type I**] [**Type II**] [**Type III**] [**Type IV**] [**Type V**].
6. Diffusers and Globes: [**Tempered Fresnel glass**] [**Prismatic glass**] [**Diffuse glass**] [**Clear glass**] [**Prismatic acrylic**] [**Clear, UV-stabilized acrylic**] [**Clear polycarbonate**] <**Insert material**>.
7. Housings:

    a. [**Extruded-aluminum**] <**Insert material**> housing and heat sink.
    b. [**Clear**] <**Insert color**> [**anodized**] [**powder-coat**] [**painted**] finish.

B. Bollard:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Shape: [**Round**] [**Square**] [**Hexagonal**] [**Fluted**] <**Insert shape or feature**>.
3. Height Above Finished Grade: [**24 inches (600 mm)**] [**30 inches (762 mm)**] <**Insert height**>.
4. Overall Height: [**30 inches (762 mm)**][**36 inches (900 mm)**] <**Insert height**>.

5. Diameter: [**6 inches (150 mm)**] <**Insert measurement**>.
6. Mounting: [**3 point cast aluminum base**] <**Insert mounting provisions**>.
7. Distribution: [**Type III**] [**Type V**].
8. Diffusers and Globes: [**Tempered Fresnel glass**] [**Prismatic glass**] [**Diffuse glass**] [**Clear glass**] [**Prismatic acrylic**] [**Clear, UV-stabilized acrylic**] [**Clear polycarbonate**] <**Insert material**>.
9. Housings:

    a. [**Extruded-aluminum**] <**Insert material**> housing and heat sink.
    b. [**Clear**] <**Insert color**> [**anodized**] [**powder-coat**] [**painted**] finish.

C. Border:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Shape: [**Round**] [**Square**] <**Insert shape**>.
3. Dimensions: [**12 inches (300 mm)**] [**square**] [**in diameter**].
4. [**Flush**] <**Insert dimension**> with grade.
5. Diffusers and Globes: [**Tempered Fresnel glass**] [**Prismatic glass**] [**Diffuse glass**] [**Clear glass**] [**Prismatic acrylic**] [**Clear, UV-stabilized acrylic**] [**Clear polycarbonate**] <**Insert material**>.
6. Housings:

    a. [**Extruded-aluminum**] <**Insert material**> housing and heat sink.
    b. [**Clear**] <**Insert color**> [**anodized**] [**powder-coat**] [**painted**] finish.

D. Canopy:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Shape: [**Round**] [**Square**] <**Insert shape**>.
3. Dimensions: [**12 inches (300 mm)**] [**square**] [**in diameter**].
4. Diffusers and Globes: [**Tempered Fresnel glass**] [**Prismatic glass**] [**Diffuse glass**] [**Clear glass**] [**Prismatic acrylic**] [**Clear, UV-stabilized acrylic**] [**Clear polycarbonate**] <**Insert material**>.
5. Housings:

    a. [**Extruded-aluminum**] <**Insert material**> housing and heat sink.
    b. [**Clear**] <**Insert color**> [**anodized**] [**powder-coat**] [**painted**] finish.

E. Decorative Post Top:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Luminaire-Mounting Height: <**Insert height of luminaire from finished grade**>.
3. Mounting Type: [**Arm**] [**Tenon**] [**Ring**].
4. Distribution: [**Type I**] [**Type II**] [**Type III**] [**Type IV**] [**Type V**].
5. Diffusers and Globes: [**Tempered Fresnel glass**] [**Prismatic glass**] [**Diffuse glass**] [**Clear glass**] [**Prismatic acrylic**] [**Clear, UV-stabilized acrylic**] [**Clear polycarbonate**] <**Insert material**>.
6. Housings:

    a. [**Extruded-aluminum**] <**Insert material**> housing and heat sink.
    b. [**Clear**] <**Insert color**> [**anodized**] [**powder-coat**] [**painted**] finish.

F. Roadway:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Luminaire-Mounting Height: <**Insert height of luminaire from finished grade**>.
3. Mounting Type: [**Arm**] [**Tenon**] [**Ring**].
4. Distribution: [**Type I**] [**Type II**] [**Type III**] [**Type IV**] [**Type V**].
5. Diffusers and Globes: [**Tempered Fresnel glass**] [**Prismatic glass**] [**Diffuse glass**] [**Clear glass**] [**Prismatic acrylic**] [**Clear, UV-stabilized acrylic**] [**Clear polycarbonate**] <**Insert material**>.
6. Housings:

    a. [**Extruded-aluminum**] <**Insert material**> housing and heat sink.
    b. [**Clear**] <**Insert color**> [**anodized**] [**powder-coat**] [**painted**] finish.

2.4 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Stainless steel. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

D. Diffusers and Globes:

1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Lens Thickness: At least 0.125 inch ((3.175 mm)) minimum unless otherwise indicated.

E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

G. Housings:

1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
2. Provide filter/breather for enclosed luminaires.

H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.
b. Lamp diameter, shape, size, wattage and coating.
c. CCT and CRI for all luminaires.

2.5 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

C. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.

a. Color: per Architect.

D. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

a. Color: As selected from manufacturer's standard catalog of colors.
b. Color: Match Architect's sample of manufacturer's standard color.
c. Color: As selected by Architect from manufacturer's full range.

2.6 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

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 luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.

C. Examine walls, roofs, and canopy ceilings and overhang ceilings for suitable conditions where luminaires will be installed.

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

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is substantially complete, clean luminaires used for temporary lighting and install new lamps.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Install lamps in each luminaire.

D. Fasten luminaire to structural support.

E. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Support luminaires without causing deflection of finished surface.

4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

F. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.

G. Wiring Method: Install cables in raceways. Conceal raceways and cables.

H. Install luminaires at height and aiming angle as indicated on Drawings.

I. Coordinate layout and installation of luminaires with other construction.

J. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

K. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES

A. Aim as indicated on Drawings.

B. Install on concrete base with top 4 inches (100 mm) above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.5 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Verify operation of photoelectric controls.

C. Illumination Tests:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):

   a. IES LM-5.
   b. IES LM-50.
   c. IES LM-52.
   d. IES LM-64.
   e. IES LM-72.

2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

D. Luminaire will be considered defective if it does not pass tests and inspections.

E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain luminaires and photocell relays.

3.9 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 265619

DIVISION 27 – COMMUNICATIONS

SECTION 270548 - VIBRATION AND SEISMIC CONTROLS FOR COMMUNICATION SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. General provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section.

1.2 SUMMARY

A. Section Includes
   1. Anchoring and restraints.

B. Related Sections
   1. Section 271500 Communication Horizontal Cabling System
   2. Section 275123 Intercom System
   3. Section 280500.2 Security & Communication Conduit / Raceway Systems.

1.3 REFERENCES

A. ASTM E2265- Standard Terminology for Anchors and Fasteners in Concrete and Masonry.

1.2 SYSTEM DESCRIPTION

A. Design Requirements
   1. Provide seismic components for the following systems:
      a. Communications Horizontal Cabling
      b. Intercom System
   2. Provide seismic restraints for the listed materials and equipment. The attachments shall resist forces to the center of gravity of the component. Criteria shall be the operating weight of the item times 0.5g for horizontal force to be applied in any direction. Wall-mounted or suspended components shall in addition, resist a downward force of 200 pounds minimum added to the operating weight.
   3. The Importance Factor (I_P) of the above systems equals 1.5.
   4. From structural sheet S0.0, the applicable seismic design parameters are as follows:
      a. Site Class (D)
      b. Occupancy Category:
         1) The following buildings are risk category II: 5 and 6
         2) The following buildings are risk category III: 1a, 1b, 2, 3 (add alt #1), 4 and 7
      c. Seismic Design Category (D).
      d. Refer to sheet S0.0 to confirm these values.

1.3 SUBMITTALS

A. Provide all required submittals under provisions of Section 013300.

B. Submit proposed system to engineer for review prior to installation.

C. Project Information:
1. Submit seismic support calculations for all electrical equipment and conduit where isolation restraints are supplied.
2. Certification of seismic restraints.
a. Substantiated by calculations or test reports verified by a professional structural engineer or equipment manufacturer.

D. Shop Drawings
1. Submit seismic restraint installation shop drawing prior to installation.

1.4 QUALITY ASSURANCE

A. Racks and Conduits: ASCE 7 Guidelines, Chapter 13 "Seismic Design Requirements for Nonstructural Components".

B. Anchor Bolts: All anchor bolts shall comply with ASTM A307.

C. Certifications: All Seismic components shall be certified as appropriate for seismic installation by the manufacturer or by a delegated design professional as specified in specification section 013300 paragraph 2.3.

PART 2 -PRODUCTS

2.1 GENERAL

A. Acceptable Manufacturers:
1. Seismic Control Devices:
a. Mason Industries.
b. Vibration Eliminator Co.
c. Korfund Dynamics Corp.
d. Amber-Booth Co.
e. Consolidated Kinetics.
f. Kinetics Noise Control

B. Provide conduit and equipment anchoring systems as indicated in the Contract Documents.

C. Provide all mounting hardware, support wires, conduits for alignment, eyebolts, bolts, nuts and washers required for equipment mounting and seismic control. Structural blocking/backing and hardware required for installation shall be provided as indicated in the Contract Documents.

2.2 ANCHORING AND RESTRAINTS

A. Equipment Anchors:
1. Anchor all equipment in accordance with the approved shop drawings.
2. Contractor shall be responsible for design and acquiring of approval for anchoring of equipment where required by ASCE 7.

B. Conduit Supports:
1. Conduits shall be supported and braced in accordance with ASCE 7 Chapter 13.

2. Conduits individually supported above finished floors with an importance factor of 1.5 and greater than 2.5 inches in diameter shall be provided with seismic restraints as required by ASCE 7, Chapter 13.
3. Trapeze supported conduits with a total weight exceeding 10 lb/ft shall be provided with seismic restraints as required by ASCE 7, Chapter 13.
4. Cable trays must be listed for seismic installation in accordance with ASCE 7, Chapter 13. Securely attach cable to tray at intervals equal to one half the cable tray support spacing.

C. Device Support:
1. Provide independent seismic support system for all boxes not directly anchored to concrete walls or concrete ceilings for the following:
   a. Wireless Access Points.

D. Floor Mounted Racks:
1. Furnish and install seismic racks and attach per manufacture's installation instructions.
2. Furnish and install seismic restraints for shelf mounted computers, monitors, and any other component not securely attached to the frame.

PART 3 -EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturers' written instructions in a manner to achieve full capacity of support.

END OF SECTION 270548

SECTION 27 1500 – VOICE, DATA & VIDEO COMMUNICATIONS CABLING SYSTEMS

PART 1 - GENERAL

Unless otherwise noted, components specified in this section may not be substituted. In an effort to streamline the operations of telecommunications infrastructure systems, Monterey County Information Technologies (MCIT) standardizes the cabling components installed in the telecommunications infrastructure systems in all facilities to minimize inventory items. When a product is listed without substitution, no other product is allowed.

1.1 RELATED DOCUMENTS

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

B. The cabling contractor shall be responsible for coordinating the installation of the conduit and raceway system by division 26 that supports the voice, data and video communications cabling systems specified under this section.

C. Section 270548 Vibration and Seismic Controls for Security Systems shall apply to supporting mechanisms for voice, data and video communications cabling systems specified under this section.

D. Should there be discrepancies between different specifications sections of this bid document, the most stringent of all shall supersede and take precedence over all others.

1.2 SUMMARY

A. This section includes provisions and installation of all parts and components that comprise the telecommunications cabling infrastructure. The deliverables of this section consists of the all components, including those incidental to and associated with the installation, termination, testing and documentation of a complete, fully functional ANSI/TIA/EIA-568-complaint structured Category 6A horizontal cabling system for voice and data systems; inside plant/outside plant (ISP/OSP) optical fiber backbone cabling systems; ISP/OSP copper backbone cabling systems; and ANSI/TIA/EIA-607-compliant telecommunications grounding and bonding system. Furnish and install all components required for a complete an operational system whether or not they are specifically identified herein. It also includes provisions and installation of Category 6A cabling.

B. Furnish and install Transient Voltage Surge Suppression on every metallic or copper cable that enters or leaves the building.

C. Furnish and install all wire, cable, fiber optic cable, fiber optic enclosures, patch panels, racks, patch cables, and miscellaneous hardware associated with or incidental to the installation of complete infrastructure backbone and horizontal cabling systems for the facility to be constructed. **Approved suppliers of the structured cabling system are Berk-Tek and Leviton, or Berk-Tek Leviton Technologies. Approved supplier of the support infrastructure components is Chatsworth Products.**

D. The infrastructure backbone cabling system shall include inside plant (ISP) and outside plant (OSP) fiber optic and copper cabling for the telephone and data networks.

E. The infrastructure horizontal cabling system shall be Category 6A copper cabling for the telephone and data networks; HDMI and Category 6A, for locations designated for specialty outlets (SO)

F. Grounding and bonding of metallic components of every cable that enters or leaves the building to the telecommunications ground busbar in the building's IDF/MDF/Electrical room

1.3 DEFINITIONS

A. The Work: A complete end-to-end, fully functional, ANSI/TIA/EIA-568-compliant structured cabling system as described in this specifications section in conjunction with all other related sections, complete with testing, certifications and as-built documentation.

B. The Contractor: The Bidder who has been awarded with a general contract which includes this section.

C. Furnish: Inter-trade coordinate, supply, provide, deliver, install, pull, fix, dress, terminate, label, test, ground, bond, and document the components as per this and other related sections.

D. Products: Deliverables of the Work defined in this section. Refer to Part 2 of this section for all specified products.

1.4 SCOPE OF WORK

A. This section includes the minimum composition requirements for the equipment and telecommunications systems cabling installations in the building, including the main distribution frames (MDF), intermediate distribution frames (IDF), electrical/security electronics rooms, and any remote locations.

B. The Work is to furnish and install a structured cabling system that is compliant with all requirements specified herein. It consists of the provision, installation, termination, testing and documentation of a complete and fully functional structured Category 6A horizontal cabling system, inside plant (ISP) optical fiber backbone cabling system, ISP copper backbone cabling system, Outside plant (OSP) optical fiber backbone cabling, and OSP copper backbone cabling systems. The drawings included in the contract document serve to diagrammatically depict at high level the design intent of the specified communications cabling system. Physical arrangement of the specified horizontal and backbone cabling systems shall be that of a star topology as described in the ANSI/TIA/EIA-568B standards document.

1.4 QUALITY ASSURANCE

A. All cabling and equipment shall be installed in a neat and workmanlike manner within the context of California Electrical Code, giving the Authority Having Jurisdiction (AHJ) the power to reject work deemed incompliant. Means and methods of construction shall be developed by Contractor to satisfy all quality requirements implicit and explicit within the standards specified herein as inferred by the AHJ.

B. Contractor shall ensure that equipment and materials are of the quality and manufacture as specified. Where "approved equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval of MCIT. Bidder shall provide detailed narratives, Underwriters Laboratory test data, mechanical properties, et cetera to establish equivalency with all supporting documents for review and approval prior to bid opening.

C. Contractor shall strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

D. Material and work specified herein shall comply with the applicable requirements of:

1. ANSI/TIA/EIA – 568 current revision and associated addenda: Commercial Building Telecommunications Cabling Standard

2. ANSI/TIA/EIA – 569 current revision and associated addenda: Commercial Building Standard for Telecommunications Pathway and Spaces

3. ANSI/TIA/EIA – 606 current revision and associated addenda: Administration Standard for the Telecommunications Infrastructure of Commercial Buildings

4. ANSI/TIA/EIA – 607 current revision and associated addenda: Commercial Building Grounding and Bonding Requirements for Telecommunications

5. ANSI/TIA/EIA 455: Fiber Optic Test Standards

6. ANSI/TIA/EIA – 526-7: Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant

7. ANSI/TIA/EIA – 526-14A: Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant

8. ANSI/TIA/EIA – 758 current revision and associated addenda: Customer-Owned Outside Plant Telecommunications Cabling Standard

9. IEC/TR3 61000-5-2 Ed. 1.0 and amendments: "Electromagnetic compatibility (EMC) – Part 5: Installation and mitigation guidelines – Section 2: Earthing and cabling"

10. ANSI-J-STD 607-A Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications

11. NFPA 70 National Electric Code with California amendments, current edition

12. ANSI/NECA/BICSI Standard for Installing Commercial Building Telecommunications Cabling, current edition

13. NECA/BICSI 607-2011 Standard for Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings, current edition

14. BICSI Telecommunications Distribution Methods Manual, current edition

15. ANSI/NECA/BICSI 568-2006, Standard for Installing Commercial Building Telecommunications Cabling

16. FCC 47 CFR 68 Underwriters Laboratories (UL) listings and ratings, including:

    a. UL 444 Communications Cables

    b. UL 1651 Optical Fiber Cable

    c. UL 1655 Community Antenna Television Cable

    d. UL 1963 Communications Circuit Accessories

E. Installation of all devices and telecommunications rooms shall be as reviewed, inspected and signed off by the MCIT Communications department in addition to approval by the Inspector on Record.

1.5 SUBMITTALS

A. Pre-installation Submittals: Provide submittal information for review as follows:

1. Provide manufacturers' product data sheets for all material and equipment as specified.

2. For components not specifically specified in this section but are incidental to and associated with installation and completeness of the specified Work to meet the standards requirements as part of quality assurance, submit the proposed manufacturer's cut sheets with descriptive and technical information.

B. Closeout Submittals – Provide submittal information for review as follows:

1. Records - Maintain at the job site a minimum of one set of Record Drawings, Specification, and Addenda. Record Drawings shall consist of redline markups of drawings, specifications and spreadsheets, including manhole (vault) and hand hole (maintenance hole) butterfly drawings.

    a. Document changes to the system from that originally shown on the Contract Documents and clearly identify system component labels and identifiers on Record Drawings.

    b. Keep Record Drawings at the job site and make available to the Owner and Engineer at any time.

    c. Keep Record Drawings current throughout the course of construction. ("Current" is defined as not more than one week behind actual construction.

    d. Show identifiers for major infrastructure components on Record Drawings

2. As-built documentation for communications cabling system - At the completion of the cabling systems specified herein, submit as-built drawings in hard copy and AutoCAD/Revit files that incorporate all changes during the course of construction, including identifier used on each component such as cable numbers, jack numbers, et cetera.

a. As-built drawings shall show locations of all components installed, including but not be limited to, locations of voice and data outlets, equipment cabinets, rack locations, telephone termination blocks, et cetera.

b. As-built test results for each cable indicating tests performed, results obtained and values measured. Test results shall be provided in electronic format with the associated application (if required) for viewing.

c. All documentation and drawings shall be provided in an electronic format (AutoCAD/Revit for drawings, MS Excel for schedule, et cetera) and supplied on CD-ROM or thumb drive.

d. As-built documentation shall be consistent with the requirements specified in ANSI/TIA/EIA 606B.

PART 2 - PRODUCTS

2.1 SPILLWAYS

A. Furnish and install at each overhead telecommunications conduit an appropriately-sized spillway.

2.2 EQUIPMENT RACKS

A. Furnish and install in the telecommunications rooms and the security rooms adjustable 4-post server racks (29.54” to 35.43”); Chatsworth Products, Inc. (CPI) adjustable P/N 15213-703.
.
1. Secure each rack with four expansion anchor bolts, Hilti P/N 00282572 KB3 SS316 Kwik Bolt 3-5/8” X 3-3/4”.
2. Coordinate with other trades for installation of building UPS system and electrical outlets specified in other divisions.
3. Anchor and secure equipment each equipment rack on the floor according to the seismic submittal that conforms to ASCE 7, seismic design category D as reviewed and approved by the architect and structural engineer on record.
4. Ground each rack individually to the telecommunications busbar in the room using 2AWG green jacketed, stranded ground conductor. All surfaces to be bonded shall be sanded or an abrasive tool be used to remove paint or any protective coating so that to provide a good bonding surface. Apply an antioxidant joint compound on all bonding connections. All bonding conductor connections shall use a two-hole lug with the holes 5/8” (center-to-center) apart and secured with two ¼” bolts. Lugs can be either a mechanical or compression type connector.
5. Furnish and install on every rack equipment support rails, CPI P/N 15235-704
6. Furnish and install on each equipment rack:
   a. (1) Vertical Power Distribution Unit (PDU), Switched Zero U, Input 208V L6-20P, Output (21) C13, (3) C19; APC P/N AP8959NA3; each with vertical mounting brackets CPI P/N 35700-701.
   b. (2) 6”Wx6”D combination cabling section (CCS) at each side of rack; CPI P/N 30165-703.
   c. (4) 2-RMU front only horizontal wire manager, CPI P/N 30130-719

7. Furnish (1) set of screws/cage nuts (25 counts per set set) per rack for project owner's use to mount network and computing equipment; CPI P/N 12639-001.

2.3 SWING GATE RACK

A. Furnish and install (1) 43" H X 18" D X 21" W universal swing gate rack in the Electrical/SEC rooms as indicated on the plans, CPI P/N 11791-X18.
   1. Furnish and install on each equipment rack (2) 1-RMU front only horizontal wire manager, CPI P/N 30139-719. Coordinate installation with all trades.
   2. Furnish (1) set of screws/cage nuts (25 counts per set set) per rack for project owner's use to mount network and computing equipment; CPI P/N 12639-001.

B. Coordinate with the exact location above incoming underground conduits to mount the swing gate rack based on field conditions, ensuring proper clearance for the rack to swing open to the maximum per manufacturer design.

2.4 CABLE RUNWAY AND ACCESSORIES

A. Cable runways shall be placed against all four walls of the telecom room as well as above the row of equipment racks from wall to wall. Use all parts and accessories as specified hereunder to construct the cable runway system, include all incidental accessories and associated parts and components per the manufacturer's most recent recommendations. Refer to the manufacturer's most current catalogs for details and requirements that are not delineated in this specification section; among others:

Parts needed to build a cable runway system include, but are not limited to, the following:

1. 12-inch alternate space cable runway, CPI P/N 31472-712
2. 12-inch universal cable runway, CPI P/N 10250-712
3. 12-inch runway radius drop, CPI P/N 12100-712
4. Support bracket for cable runway, CPI P/N 11746-712
5. 12-inch wall angle cable runway support kit, CPI P/N 11421-712
6. Channel rack to runway mounting plate, CPI P/N 12730-712
7. 12-inch cable runway radius outside bend, CPI P/N 10723-712
8. 12-inch cable runway radius inside bend, CPI P/N 10724-712
9. 12-inch cable runway movable cross member, CPI P/N 12115-712
10. 24-inch wide cable runway corner bracket, CPI P/N 11959-715
11. UL classified heavy duty butt splice kit, CPI P/N 16299-001
12. UL classified heavy duty junction splice kit, CPI P/N 16298-001
13. Double earthquake brace, CPI P/N 10696-001
14. J-bolt kit, CPI P/N 11308-001
15. Cable runway elevation kit, CPI P/N 10506-706
16. 12-inch triangular support bracket, CPI P/N 11312-712
17. 12-inch center support kit, CPI P/N 12362-712
18. 12-inch end closing kit, CPI P/N 11700-712
19. Combination pan head, pilot point, mounting screws, CPI P/N 40605-001
20. Cable runway slip-on threaded support bracket, CPI P/N 10873-001
21. Vertical wall bracket, CPI P/N 10608-701
22. Slotted support bracket 5/8" thread rod, CPI P/N 11607-001
23. Compression connector Lug #2, CPI P/N 40162-904
24. Butt swivel splice, CPI P/N 10487-701

25. Junction swivel splice, CPU P/N 10488-701
26. Vertical swivel, CPI P/N 10489-701
27. Threaded rod ceiling 5/8" support, CPI P/N 11406-001
28. End caps, CPI P/N 10642-001
29. Threaded ceiling kit, CPI P/N 11310-003
30. Ladder rack foot kit, CPI P/N 11309-001

2.5 GROUNDING ACCESSORIES

A. Determine grounding conductor according to the conductor length.

Length in Linear Footage	Conductor Size (AWG)
Less than 13	6
14 to 23	2
24 to 41	1
42 to 52	1/0
53 to 66	2/0
Greater than 66	3/0

1. 6 AWG stranded ground wire (green) THHN, Harger P/N 6-19G
2. 2 AWG stranded ground wire (green) THHN, Harger P/N 2-19G
3. 1/0 AWG stranded ground wire (green) THHN, Harger P/N 1/019G
4. 2/0 AWG stranded ground wire (green) THHN, Harger P/N 2/019G
5. 3/0 AWG stranded ground wire (green) THHN, ALT P/N 2870-THHN-GI
6. BICSI & ANSI/EIA/TIA ground bus bar, 20" TMGB Pattern, CPI P/N 40153-020
7. L bracket for cable runway to support grounding wire, CPI P/N 11268-001
8. Rack base insulator kit, CPI P/N 10605-019
9. #6 ground strap, CPI P/N 40164-001
10. ¼" compression lugs, CPI P/N 40162-901

2.6 FIBER OPTIC BACKBONE CABLING SYSTEM

A. Singlemode fiber cables shall consist of indoor/outdoor rated fiber optic loose tube cables covered with a plenum-rated jacket to prevent snags during installation; Berk-Tek P/N OPD002AB0403.

B. OM3 Multimode fiber cables shall consist of indoor/outdoor rated fiber optic loose tube cables covered with a plenum-rated jacket to prevent snags during installation; Berk-Tek P/N OPDD12B024EB3010/25.

C. Fiber enclosure(s)/fiber patch panels in telecommunications rooms, security electronics rooms, and the MDF room shall be Leviton 5R1UH-S03.

D. Fiber terminations:

1. All multimode fiber terminations for intra-building cabling shall be SC type connectors, Leviton 49991-5SC.

2. All fiber connectors for security electronics systems shall be ST or SC as coordinated with the equipment provider.

E. Fiber patch cords

1. Furnish 24 (24) multimode 50/125 SC to SC 1-meter patch cables, Leviton P/N OR-626DF2LR-FF001M.

2.7 CATEGORY 6A HORIZONTAL CABLING

A. Cables

1. Category 6A cables shall be BerkTek LANmark-1000, UTP, Category 6A Plenum rated, P/N 10032092.

B. Connectors

1. Category 6A jacks for horizontal cabling at work areas shall be Leviton eXtreme 6A channel rated connectors.

C. Faceplates and Surface Boxes

1. Match faceplate color with cable color. Unused ports shall be covered with insert covers of the same color.

D. Patch Panels

1. Category 6A patch panel for horizontal cabling shall be Leviton Extreme CAT 6A flat patch panels.

2.8 INSTALLATION

A. Equipment shall be installed according to manufacturer’s instructions and properly mounted to a rack, cabinet, bracket or other appropriate mounting device.

B. Panels shall be properly labeled on front and back with the cable number and port connections for each port.

C. Racks shall be assembled such that mounting rails are exactly perpendicular to the base.

D. Racks shall be secured to the floor using appropriate anchors.

E. Racks shall be grounded to an appropriate building ground using a minimum #6 grounding wire or as indicated on drawings.

F. Faceplates shall be labeled with the appropriate port designations as per the EIA/TIA standard.

2.9 TESTING

A. General Testing Criteria (Applies to all cable certification testing)

1. All cabling not tested strictly in accordance with these procedures shall be retested at no additional cost to the project.

2. 100 percent of the installed cable shall be tested.

3. All Category 6A UTP Cable, Multimode, and Single Mode Fiber Optic Cable tests shall be performed using the Fluke DTX 1800 CableAnalyzer (Tester) and the Fluke DTX 1800 SmartRemote (Remote) Model cable tester set, or equal. The Contractor shall indicate the software revision installed on the test equipment is the most current available from the cable tester manufacturer prior to commencing any final cable tests for record.

4. All cables, Horizontal, Intra-building Backbone Cable, and Inter-building Backbone Cable, shall be tested prior to the cutover of voice and data systems. Complete test results by cable type, including a Summary Report shall be presented to Project Engineer.

5. Test results shall be provided in electronic report format. Handwritten test reports are not acceptable. Electronic reports must be accompanied by a Certificate signed and stamped by an authorized RCDD representative of the Contractor warranting the truth and accuracy of the electronic report data. The certificate must reference traceable cable/fiber numbers that match the electronic record.

6. Test reports shall include the following information for each permanent Cat 6A copper cable link or permanent optical fiber link (MM and/or SM) tested:
   a. Tester manufacture, model, main unit serial number, remote unit serial number, main unit adapter type, remote unit adapter type, software version, operator.
   b. Cable number and project/job name.
   c. Date and time of test.
   d. Overall pass/fail indication.
   e. Wire map results that indicate the permanent cable link tested has no shorts, opens, split, reversed or crossed pairs, and end-to-end connectivity is achieved.

7. Any individual test that fails a relevant performance parameter shall be marked as a FAIL and the Contractor shall indicate the action taken to correct the problem.

B. Category 6A Voice/Data Cable Certification Testing

1. All testing shall be performed in conformance with EIA/TIA 568-B.2 using the permanent link test setup. Cabling shall meet the performance specifications for Category 6A specific to TIA/EIA 568 B.

2. Save and submit all tested cable results.

3. Tests with PASS* and FAIL* notation are to be identified in the cable summary report.

4. All cable tests must pass prior to acceptance.

D. Copper Feed Certification Testing

1. All copper backbone cables shall be tested for shorts, opens, split, reversed or crossed pairs, and end-to-end connectivity using the Fluke CableAnalyzer or equal.

2. The Tester should be connected to a commercially available test adapter that allows the connection of the RJ-45 modular plug on the Fluke CableAnalyzer to a 110 termination block.

E. Special Services Patch Panel Certification Testing

1. All copper special services patch panel cables shall be tested for shorts, opens, split, reversed or crossed pairs, and end-to-end connectivity using the Fluke CableAnalyzer or equal.
   a. The Tester and Remote Units should be connected to the DTX PLA002 Cat 6A Permanent Link Adapters. The Tester shall be connected to the RJ-45 jacks installed within patch panels. The Remote shall use a modular plug adapter on the Fluke CableAnalyzer to test the far end terminations on 110 termination blocks.

F. Fiber Certification Testing

1. The Contractor shall be responsible for testing every strand of each Intrabuilding and Interbuilding fiber optic backbone cable.
   a. All strands in each cable shall be terminated, mounted in a fiber distribution/patch panel, labeled and tested.
   b. The installed fiber link(s), each consisting of two (2) fibers/strands (Tx and Rx). Multimode fiber will be tested as specified by TIA/EIA-568-B.1.7.1 and ANSI/TIA/EIA 526-14A Method B. Singlemode fiber will be tested as specified by TIA/EIA-568-B.1.7.1 and ANSI/TIA/EIA 526-7 Method A.1. Method A tests the loss (attenuation) of the fiber one connection at the end of the fiber. Method B and Method A.1 test the loss the fiber and the connections at both ends of the fiber.
   c. Perform end-to-end, bi-directional power loss tests at 850nm and 1300nm wavelengths for multimode, and 1310nm and 1550nm for singlemode fibers.
   d. The following maximum allowable Loss budgets apply for cable and connectors:
      1) Connectors: Maximum allowable Loss per mated connector pair: 0.50dB
      2) Fiber: Maximum allowable attenuation for each fiber strand shall not exceed the calculated maximum Loss rating based on performance as stated by manufacturer of the cable under test.
   e. If the connector exceeds the power loss margin, then re-polish and/or re-terminate the connector and repeat the testing procedures above.
   f. If a fiber strand in the cable exceeds the specified power loss budget, then the contractor shall notify the Engineer as soon as possible to determine the impact of cable replacement on the Project Schedule. The engineer and the Contractor will devise a plan to procure new materials and replace the faulty cable.
   g. Record and document the length and power loss readings in relative decibels (dB) for every strand. Indicate as part of the testing documentation those runs that exceeded the power loss margins and the action taken (re-pulling the cable, re-polishing or re-terminating the connector).

G. Submit copies of all test reports in electronic format to the Engineer after tests are performed.

2.10 SPARE PARTS

A. Furnish to the owner the following spare parts:
   1. 5 of each type of wall outlet installed.
   2. One spare patch panel of each type installed.
   3. 2 new and unused punch down tools for cat 6A patch panels.
   4. All remaining screws from each tel-data rack installed.

B. Spare parts shall be packaged in appropriate protective packing material.

C. Box spare parts for easy storage and clearly identify the contents of each box on all four sides of each container.

END OF SECTION 27 1500

SECTION 274113 - CABLE TELEVISION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Scope of Work: Furnish and install all components as required for a complete Cable Television Signal Distribution System. Coordinate the final signal source with the owner's representative.

B. The ESC as defined in Section 280500 Common Work Results for Electronic Safety and Security shall be responsible for providing and coordinating this system.

C. The base project will provide a signal distribution system for a future source to be provided by the owner. System is to include Broadband Distribution Amplifiers, two agile modulators, splitters, coaxial cable, fiber, and all necessary parts as indicated on the SE drawings.

1.2 SUBMITTALS

A. Basic Submittals: Furnish submittals as required by Division 28 General Conditions and as required by the general contract documents.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Acceptable Manufactures:
1. Blonder Tongue, Inc
2. Scientific-Atlanta, Inc
3. Pico Macom, Inc
4. Toner Cable Equipment, Inc

Note: Approval of manufacturers does not relieve the manufacturer from providing equipment that fully complies with the specification.

2.2 SIGNAL DISTRIBUTION EQUIPMENT:

A. Terminating Resistor: Furnish and install terminating resistors for all unused ports in the distribution system as follows:
1. 75 ohm impedance
2. Rated for a frequency range from 5 MHZ to 890 MHZ
3. Return loss rating of 25 dB at UHF and 30 dB across the VHF band.

B. Broadband Distribution Amplifier: Furnish and install a wall mounted CATV amplifier equal to Blonder Tongue BIDA 550-50 as follows:
1. 50 dB gain.
2. Frequency range of 47 to 550 MHz.
3. Attenuation control of 15 dB.
4. Channel loading of 77.

C. Fiber Receiver and Broadband Distribution Amplifier: Furnish and install a wall mounted fiber optic receiver module integrated with a broadband distribution amplifier equal to Blonder Tongue FRDA-S4A-860-FA.
   1. 43 dB gain.
   2. Frequency range of 47 to 860 MHz.
   3. Attenuation control of 10 dB.
   4. Channel loading of 110.
   5. LED for optical input status.

D. Directional Couplers: Furnish and install Blonder Tongue model SDC-4 eight (8) dB directional couplers as indicated on the plans for a complete and operational system.

E. Splitters: Furnish and install 2-way, 3-way, 4-way, 6-way, or 8-way splitters, Blonder tongue series SCVS-# with a frequency range up to 1000 MHz.

F. Outlets: Furnish and install pass through connectors on unbreakable Nylon outlet plates for installation in dayrooms, medical and detainee holding cells as indicated on the plans.

G. Furnish and install TV outlets as indicated on the plans.

H. Furnish and install TV outlet in the classrooms, bonus rooms, administration conference room and lobby as indicated on the plans.

I. Furnish and install two Agile Modulators to insert local educational programming into the CATV system. Modulators shall be equal to Blonder-Tongue HAVM-1HA.

J. Coaxial Cable: Furnish and install coaxial cable for signal distribution inside each housing unit as indicated on the plans. Coax cable shall be of 75 ohm impedance RG-59/RG-6 with a return loss of 2 dB minimum from 7 MHZ to 806 MHZ. Cable construction shall be copper-clad steel center conductor and cellular polyethylene dielectric. Cable shall be installed with two shields. The first shield shall consist of .002" double aluminum coated mylar or polypropylene tape with 1.8" overlap. The second shield shall be 40% coverage aluminum braid consisting of 34 AWG wire. The jacket shall be black non-contaminating low temperature polyvinyl chloride. Cable shall be equal to West Penn AQC843 for RG-59 or West Penn AQC841 for RG-6. Cable shall be wet rated if placed in conduit underground.

K. Attenuators: Furnish and install FAF and FAM fixed attenuators in the values necessary to balance the signal distribution system. Units shall be rated for:
   1. Frequency range of 5 to 890 MHz.
   2. 75 ohm impedance systems.

L. Monitors: Television monitors and mounting brackets shall be furnished and installed by the owner.

M. Furnish and install two strands of single mode fiber for all signal transmission between the CATV source signal in the MDF room 155 in the Administration building and the cabinets in each Security Electronics room.

2.3 FIBER OPTIC MODULES

A. Furnish and install all fiber optic modules required to distribute the TV signal from the signal source to each area SEC room.

B. Modules to be mounted on CATV board in each area.

C. Fiber to be continuous from the signal source transmitter to the signal receivers in the SEC rooms.

D. Fiber Optic Transmitter: Furnish and install a fiber optic transmitter equal to Blonder Tongue model FIBT-S3A-812A. Unit shall provide:
1. 110 channels ranging from 45Mhz to 860 Mhz.
2. +12 dBm Output
3. FC/APC connector
4. Utilize 1310 nm single mode fiber
5. LED indication for quick assessment of RF input, Laser, and Cooler Status
6. Status/Alarm jack on rear of panel for Monitoring 5 key parameters.

E. Fiber Optic Coupler: Furnish and install a fiber optic Coupler equal to Blonder Tongue model FOC-23-16-U series.
1. 19” Rack Mount.
2. 1 fiber input with 6 fiber outputs as required by the configuration.
3. Low insertion loss with high directivity.

F. Fiber Optic Receiver: Furnish and install a fiber optic receiver equal to Blonder Tongue model FIBR-S4A-860 series. Unit shall provide:
1. Operation for 45 Mhz to 860 Mhz bandwidth.
2. LED for optical input status.

PART 3 - EXECUTION

3.1 COORDINATION

A. Preliminary Coordination: Coordinate all required embeds, block-outs, and construction as required to install the all television devices.

B. Construction Examination: Monitor ongoing construction and coordinate all equipment.

C. Structural Examination: Examine locations to ensure the supporting structures will carry monitor mounts and devices to be installed.

3.2 INSTALLATION

A. Coordination with Other Trades: The contractor shall coordinate the work of this section with that of other Divisions as required to ensure that the entire work of this Project will be carried out in an orderly, complete and coordinated fashion.

B. Doors: All equipment terminations must be installed clear of the door’s racks and cabinets to allow proper closing.

C. Listing: All wiring and raceways shall be listed for the intended installation and installed in strict accordance with the National Electric Code as required by the conditions of where it is installed.

D. Field Wiring: The wiring shall be installed in raceways and equipment enclosures with other conductors, within limitations defined by Article 725 of the California Electric Code.
   1. Installation: Dress wires and cables to provide a neat and orderly appearance within all enclosures, equipment racks, cabinets, and consoles by routing in snap-cover, plastic wiring duct. In locations where wiring duct is not feasible, organize by cable clamping, dressing and tie-wrapping.
   2. Strain Relief: Relieve strain on all loose wire bundles using tie-wrap, supports fastened with machine screws or bolts. Do not use self-adhesive type supports.
   3. Shrink Tubing: Neatly form cable ends and apply shrinkable tubing to shielded cables or where necessary to secure the insulation against fraying or raveling.
   4. Edge Protection: Install edge protection materials on edges, holes, lips of ducts, or any other place where wires or cables cross sharp metallic edges.
   5. Service Loops: Allow sufficient service loops where conductors leave cabinet or transition to door mounted electronics.
   6. Splicing: Field wiring shall not be spliced. All wiring shall be continuous from the field device to the termination in the control panel.
   7. Listings: Wiring shall be listed for the installation. Wire identified herein is intended to provide electrical characteristic requirements.
   8. Wire Termination: All wiring shall be terminated at both ends and labeled in accordance with the equipment wiring plans. Wire not energized or connected to active devices shall be labeled for future use.

E. Seismic: The entire system shall be installed to meet the seismic requirements for the area.

3.3 FIELD QUALITY CONTROL

A. Use attenuators as required to balance the system so that each television outlet Furnish and installs signal strength at 500 MHz between six (6) dB and nine (9) dB.

B. Use the appropriate test equipment to measure the final signal strength at each outlet in each dayroom and cells.

C. Record dB readings for each outlet. Furnish copies of all readings to the owner. These test reports as well as a monitor for viewing shall be available during final testing onsite.

CATV VERIFICATION AND CHECK-OUT FORM

✓ = OK

Job #
Job Name:
Panel #

FIELD TEST CODE:		**REPAIR CODE:**	
A - No status change	M -	1-SSI	Software Test By:_____Date_____
B - No power to TV	N -	2-ELECTRICIAN	
C - No audio	O -	3-IRONWORKER	Hardware Test By:_____Date_____
D - Poor audio	P -	4-CARPENTER	
E - Poor video	Q -	5-OWNER/REP	System Test By:_____Date_____
F - No TV signal	R -	6-ENG	
G - Program problem	S -	7 -	Design Engineering By:_____Date_____
H - Not installed	T -	8 -	
I - Dayroom TV connection	U -	9 -	Wiring By:_____Date_____
J - Cell TV connection	V -	10 -	
K - No dB reading record	W -	11 -	Field Test By:_____Date_____
L -	X -	12 -	

							ON-SITE				
ICON ID#	**ICON TYPE**	**STA CALL NO.**	**VV INTLK WITH**		**SOFT-WARE TEST**	**VV TEST**	**FIELD TEST CODE**	**REPAIR CODE**	**RE-CHECK "X"**	**FIELD CHECK OUT NOTES**	**PROBLEM RESOLVED (BY/DATE)**

3.4 SPARES

A. Furnish to the owner the following spare parts:
   1. Two of each type of splitter installed.
   2. One of each type of fiber reviver/coupler/transmitter device.
   3. One of each value of Attenuator.
   4. One directional coupler.

B. Spare parts shall be packaged in their protective packing material.

C. Box spare parts for easy storage and clearly identify the contents of each box on all four sides of each container.

END OF SECTION 274113

SECTION 27 41 16 – ASSISTED LISTENING SYSTEM

PART 1 - GENERAL

1.01 SCOPE

A. Provide a complete portable assistive listening system.

B. The system shall meet ADA requirements for assistive listening systems for the hearing impaired.

1.02 QUALITY ASSURANCE

A. All materials shall comply with applicable standards of the Underwriter's Laboratories, Inc.

1.03 SUBMITTALS

A. Submit product information data.

1.04 DESCRIPTION

A. Work under this section includes all equipment, labor and materials necessary to furnish and install a complete assistive listening system.

B. The assistive listening system shall be an RF portable wireless system.

C. Each system shall be complete consisting of transmitter, receivers, earphones, microphone, etc. as required.

D. Features:

1. Portable
2. Single channel receivers are pre-tuned, users control their own volume.
3. Easily expanded, no limit to number of users.
4. Excellent sound quality, inherently free from interference.
5. Automatic Gain Control for stable listening level.
6. High performance frequency synthesized, phase-locked-loop tuning.
7. 8 channels available.
8. Can be powered by a 12 V battery for portable operation.
9. Choice of balance or unbalanced inputs.
10. Input attenuator and low frequency attenuator control switches.
11. LED Power and Audio Level Indicators.
12. 17 fixed narrow-band frequencies in range of 72 to 76 Mhz.

PART 2 - PRODUCTS

A. All equipment shall be the standard cataloged products of a single manufacturer. The catalog numbers of the following equipment are those manufactured by TELEX – System SM-2. Equal products by LISTEN, PHONIC EAR, or other manufacturer's shall be considered for equal.

2.01 PORTABLE TRANSMITTER (1)

A. ST-300 base Transmitter, portable belt pack transmitter with lapel microphone, adjustable 16 channel, 2 audio inputs.

2.03 RECEIVERS (4)

1. Model SR-50 single fixed channel receivers.

A. Model SR-100 16-channel adjustable frequency receivers. (1 per system, 2 total).

2.04 EARPHONES (4)

A. SEB-1 dual earbud with cord for normal to moderate hearing loss. (Provide 1 for each receiver)

2.05 BATTERIES

A. Provide with long life alkaline batteries, "Energizer" or "Duracell", for each device requiring batteries such as portable transmitters and receivers.

2.06 WALL PLAQUE

A. Provide sound reinforcement wall plaque per ADA requirements to indicate equipment available for the hearing impaired. Verify location with the Architect prior to installation. Submit sample for approval. Use the "international symbol of access for hearing impaired".

2.07 CARRY CASE

A. Model SM portable carry case for SM-2 system.

PART 3 - EXECUTION

3.01 TESTS AND ADJUSTMENTS

A. Under completion of the installation of all equipment, and when same is in full operating condition, the Contractor shall perform the initial post completion tests and adjustments as specified hereinafter. Except as otherwise specified, this Contractor shall provide all instruments, equipment, labor and materials necessary to complete the tests.

3.02 WARRANTY

A. The manufacturer shall guarantee the system and components against defective material and workmanship for a period of one year from the date of final acceptance by the Owner.

END OF SECTION

SECTION 27 5123 - INTERCOM SYSTEM

PART 1. GENERAL

1.01 SUMMARY

A. Scope of work: Furnish and install all components to provide a complete and operational intercom system as described herein.

B. The ESC as defined in Section 280500 Common Work Results for Electronic Safety and Security shall be responsible for providing and coordinating this system.

1.02 SYSTEM DESCRIPTION

A. Intercom Control: The intercom system shall provide two-way communications from each area to a master control station. Master control stations are located at Touchscreen Control Stations (TCS). Communications shall be established between the TCS and the intercom stations throughout the facility as indicated on the plans. Intercom stations are task group assignable. (See Control Matrix Specification section 284600.1).

B. Furnish and install an intercom station (IC) as indicated on the plans, to allow youths and staff to place a call and communicate verbally to the assigned TCS. The intercom station shall consist of a call button and a speaker/intercom.

C. Intercom Annunciation: When an intercom call is placed, the related intercom icon will flash on the TCS monitoring the area until the call is answered. Once answered, the icon will illuminate steady until another station is selected or the system is reset.

D. Intercom Answer: Activating the appropriate icon on the TCS shall connect the intercom voice path from the TCS to the related intercom speaker for communication.

E. Youth Monitoring: The intercom system into youth areas shall not utilize any tone or audible signal that the audio path is open.

F. Provide a dome lamp (DL) where indicated on the plans. Dome lamp shall be mounted above each door to signal roving staff. Dome lamp shall illuminate whenever a call in the room is activated.

G. Call buttons (C) shall be provided for calls from critical locations to staff as indicated on the plans. Call buttons shall consist of a call button only. Activating a call button shall illuminate the dome lamp associated with the call button.

H. Dome Lamp Reset button: Furnish and install a security reset button (RB) as indicated. Furnish single gang plate made of 11-gauge stainless steel. Unit shall mount to a shallow single gang box. It will allow the staff to turn off the dome lamp.

I. Intercom Recording: Activating the appropriate icon on the TCS shall record the intercom activity in non-contact visitation. (Building 4 Room 138 and 141) Refer to SE1.4.1.

J. Furnish and install a standalone intercom system between Building 4 Pre-Booking room 118 and Processing room 110. Refer to SE1.4.1.

1.03 SUBMITTALS

A. Basic Submittals: Provide submittals as required by the Common Work Results.

B. Special Submittal Requirements: In addition to the general requirements for submittals, provide the following for approval:
1. System interconnection one-line diagram.

1.04 SYSTEMS INTEGRATION

A. Integration: Integrate the intercom system with the IP Video system to provide the following:
1. When an intercom call is selected by the TCS station, the camera monitoring the area will automatically be called up on the spot monitor associated with the TCS station.

PART 2. PRODUCTS

2.01 ACCEPTABLE SYSTEM MANUFACTURERS
A. Acceptable Manufacturers:
1. Accurate Controls
2. CMLRW Security
3. Com-Tec Security, Inc.
4. Cornerstone Security Electronics
5. Metroplex Control Systems.
6. Sierra Detention Systems

2.02 ACCEPTABLE EQUIPMENT MANUFACTURERS
1. Quam
2. Tech Works
3. Rauland
4. Biamp
5. Phoenix Contact

2.03 EQUIPMENT

A. All major electronic components shall be on printed circuit boards. The printed circuit boards shall utilize **push-on connectors with set screw terminal connections** (Phoenix Contact Type MSTB, screw-type, 24-12AWG, strand or solid) or equal for ease in maintenance and replacement. Push-in wire connections will not be allowed.

B. The system shall provide for two-way conversations between a TCS and the selected intercom station. The system shall allow one (1) two-way conversation to occur for each TCS. Each intercom station may communicate with the TCS to which it is directly connected. A TCS shall be able to connect to any intercom that is in the station's assigned task group. For TCS equipment refer to Specification section 284600.

C. The master intercom station shall consist of, but not be limited to the following: Remote speaker, remote microphone with press-to-talk switch and master intercom amplifier which

shall be modified to perform the described functions. Provide a master intercom station for each TCS indicated on the plans.

1. The master intercom amplifier shall comply with the following specifications:
   a. Equal to the Tech Works ICA-202D.
   b. Output: 20 Watts RMS into 25 V loads.
   c. Frequency Response: from 250 Hz to 10,000 Hz.
   d. Speaker Output: 8 ohms @ 2V maximum
2. The microphone shall be equal to Astatic 878HL providing the following:
   a. Frequency Response: from 50 Hz to 12,000 Hz.
3. The speakers shall be equal to the Sony SRS-A212 associated with the TCS. Refer to Specification 284600 for additional information.

D. Intercom stations shall be flush mounted with 11 gauge stainless steel security cover plate equal to the quam CIS2 where shown on the drawings.
   1. The intercom stations shall comply with the following specifications:
      a. Speaker: 3” water resistant.
      b. Impedance: 8 ohm with 25V matching transformer
      c. Microphone Sensitivity: 87dB SPL
      d. Finish: Brushed stainless steel
      e. Pushbutton: SPST normally open.
      f. Dimensions: 7-1/2” L x 5-1/2” H x 1-3/4” D
      g. Backbox: Three gang electrical back box RACO 697. ESC to coordinate back box with electrical.
      h. Mini turret (for Desk Mounted Intercom Station): Hammond Manufacturing SCEM Series (or equal).

E. Intercom Relay Board:
   1. Furnish and install relay board equal to the Quam RSP-1 with the following features:
      a. Screw terminals for connections from field intercoms.
      b. Furnish and install quantity required to operate stations indicated on plans.

F. Pedestals: Furnish and install heavy-duty pedestals for intercom stations at vehicle sallyports as indicated on the drawings. Pedestal shall be height adjustable and shall be anchored to a concrete base. Provide hooded intercom stations with surface boxes. Pedestal shall be constructed of round pipe allowing the housing to spin with out breaking if sufficient pressure is applied from the side.

G. Call Button: Furnish and install detention grade Call buttons equal to Quam CIB2 as indicated on the plans. Call Button shall consist of a heavy-duty push button on a single gang plate. Unit shall be constructed of 11-gauge stainless steel and designed for installation in a detention facility.

H. Dome Lamp: Furnish and install security dome lamp equal to the Com-Tec CTS-3041 Series, above each door as indicated. Unit shall be made of a high impact molded laminate bubble attached to an 11-gauge stainless steel single gang plate. A single lamp shall be provided.

I. Dome Lamp Reset button: Furnish and install security reset button (RB) equal to Quam CIB2 where indicated on the plans. Furnish single gang plate made of 11-gauage stainless steel. Unit shall mount to a standard single gang box.
   1. Finish: Brushed stainless steel

2. Pushbutton: detention grade SPST normally open equal to intercom station button.

J. Talk Path: Each TCS shall have an independent talk path allowing simultaneous communication from all TCS to the stations under their control. Intercom stations can establish a talk path with only one master at a time.

K. Recorder: An audio logging recorder equal to Gemini DRP-1 Digital Recorder will be attached to an intercom amplifier equivalent to TechWorks ICA-202D amplifier and installed as shown on page 29 of the manual. This amplifier will be connected to intercoms 441 and 438 in Non-Contact Visitation so central control can record the conversation. Mount Recorder and Amplifier in Central Control.

L. Provide a Talk Perfect DX Duplex Intercom (or Equal) in the Pre-booking area (Building 4 Rooms 118 and 110). Mount amplifier under counter in Room 118. Coordinate power with electrical contractor in room 118.
1. Unit shall provide hands free full duplex operation once a connection has been established.
2. Provide speakers on each side equal to Talk Perfect TP-PDS desk mounted Stainless Steel Speakers.
3. Provide microphone on each side equal to Talk Perfect TP-PMS desk mounted Stainless Steel Microphone.

2.04 TRANSIENT SURGE SUPPRESSION

A. Acceptable manufacturers are as follows:
1. Northern Technologies Incorporated
2. DITEK
3. PolyPhaser Corporation
4. Transtector

B. Intercom Suppression: Provide surge protection for intercom wiring that leaves the building. Provide Northern Technologies series PLP units matched to the voltage of the circuit suppressed. The suppressors shall have a peak pulse power dissipation rating of 10 joules each mode, minimum.

C. Security System Power: Provide surge protection for all power connections both inside and outside the building. Devices shall be equal to Northern Technologies TCS-HWR series rated for the power of the circuit suppressed. The suppressors shall have a peak pulse power dissipation rating of 300 joules L-N, minimum. Units shall provide a dry contact monitored by the security system and identified by electrical panel circuit number.

2.05 FIBER OPTIC MODULES

A. Furnish and install all fiber optic modules required for transmitting audio between buildings.

B. Certain intercoms in each building are controlled from Central Control.

C. Furnish and install a fiber optic module pair to establish one audio link from each building to central control over fiber.

D. Furnish and install fiber optic modules to establish an independent audio link from the vehicle sallyport intercoms to central control over fiber.

E. Modules to be located in a common module rack located next to the fiber optic patch panel (or LIU) in each building. Module shall be equal to AFI 89D series.

2.06 CABLING AND WIRE

A. Acceptable manufacturers:
   1. Liberty Wire and Cable
   2. Eastman Wire & Cable
   3. West Penn Wire
   4. Belden
   5. Carol
   6. General Cable
   7. Clifford of Vermont, Inc.

B. Wire Size: Furnish and install sufficient wire gauge to limit voltage drop to 5%.

C. Intercom: Intercom wiring shall be compatible with the equipment provided.
   1. Nominal outer diameter shall be a maximum of .2240 inches.
   2. Provide one shielded pair plus two conductors – 22 AWG.
   3. For dry Locations intercom wiring as a minimum shall be equal to West Penn 357. Wet rated cable may be run in dry locations at the contractor's option.
   4. For wet locations, furnish and install cable with water-blocked tape equal to AQC357. All locations that come in contact with the building slab are considered wet locations in accordance with code.

D. Call Button (C): Wiring for call button shall be a two #20 AWG stranded conductors equal to a West Penn AQC292.

E. Reset Button (RB): Wiring for reset button shall be a two #20 AWG stranded conductors equal to a West Penn AQC292.

F. Dome Lamp (DL): Wiring for dome lamp shall be a four #20 AWG stranded conductors equal to a West Penn AQC292.

G. Fiber Media Converter (voice path): Furnish and install one (1) OM3 fiber strand per voice path.

2.07 EQUIPMENT ENCLOSURES

A. Acceptable Manufacturers:
   1. Lowell
   2. AMCO Cabinets.
   3. Hoffman
   4. HOME

B. Cabinets: Mount intercom equipment in minimum 83" high by 27" deep by 23" wide free standing cabinets as indicated on the plans equal to LSER-4427. Size cabinets to accommodate all system components.
   1. Cabinets shall be constructed of cold rolled steel and provide standard mounting rails for 19" rack mounted equipment.
   2. Conduit shall enter from the top.
   3. Low voltage wiring shall be separated from 120 volt wiring.
   4. Intercom equipment may be mounted with PLC or IP Video control equipment.
   5. Furnish and install mounting hardware as required to install all intercom security electronics equipment required in the space allowed.
   6. Furnish and install solid metal doors for access to both the front and back. Doors shall be minimum 16 gauge flush mounted with air louvers and flush pulls.
   7. Side panels shall be a minimum of 16 gauge flush mount.
   8. Both front and rear doors shall be provide with key locks. Furnish two (2) door keys.
   9. Furnish and install ventilation fans as required to enable proper ventilation for the equipment.
   10. Coordinate cabinet power receptacles with and Division 26.
   11. Furnish and install blank plates by manufacturer on all unused rack sections.

C. Refer to Specification Section 270548 for Seismic Requirements for Equipment Enclosures.

PART 3. EXECUTION

3.01 COORDINATION

A. Preliminary Coordination: Coordinate all required embeds, block-outs and boxes.

B. Control Coordination: Verify that all stations are provided with an appropriate control and an annunciating icon on the TCS.

C. Coordinate system power and conduit with Division 26.

3.02 INSTALLATION

A. Speakers: Initially tap all speakers at the lowest tap provided. Move to higher taps in high noise areas to balance the page output throughout the facility. All attenuation controls shall be set to the minimum practical level. All costs for balancing shall be included in the base bid. Record and submit with closeout documents listing all tap settings.

B. Devices: Install all devices per manufacturer's recommendations. Square devices shall be installed with the bottom line parallel with the floor at designated heights.

C. Intercom Stations: Initially tap all intercom stations at the lowest tap. Move to higher taps in high noise areas. Verify the device is installed with security screws.

D. Call Buttons: Check wiring connection at all call buttons. Verify the device is installed with security screws.

E. Dome Lamp: Check wiring connection at all dome lamp. Verify the device is installed with security screws.

F. Reset Button: Check wiring connection at all reset button. Verify the device is installed with security screws.

G. Field Wiring: The wiring shall be installed in raceways and equipment enclosures with other conductors, within limitations defined by Article 725 of the California Electric Code.
   1. Installation: Dress wires and cables to provide a neat and orderly appearance within all enclosures, equipment racks, cabinets, and consoles by routing in snap-cover, plastic wiring duct. In locations where wiring duct is not feasible, organize by cable clamping, dressing and tie-wrapping.
   2. Strain Relief: Relieve strain on all loose wire bundles using tie-wrap, supports fastened with machine screws or bolts. Do not use self-adhesive type supports.
   3. Shrink Tubing: Apply shrink tubing neatly for cable ends to shielded cables or where necessary to secure the insulation against fraying or raveling.
   4. Edge Protection: Install edge protection materials on edges, holes, lips of ducts, or any other place where wires or cables cross sharp metallic edges.
   5. Service Loops: Allow sufficient service loops where conductors leave cabinet or transition to door mounted electronics.
   6. Splicing: Field wiring shall not be spliced. All wiring shall be continuous from the field device to the termination in the control panel.
   7. Listings: Wiring shall be listed for the installation. Wire identified herein is intended to provide electrical characteristic requirements.
   8. Wire Termination: All wiring shall be terminated at both ends and labeled in accordance with the equipment wiring plans. Wire not energized or connected to active devices shall be labeled for future use.

3.03 SPARE PARTS

A. Furnish to the owner the following spare parts:
   1. One (1) spare intercom amplifier
   2. Four (4) spare intercom stations.
   3. Two (2) spare intercom control cards or one (1) relay board.
   4. One (1) call button.
   5. One (1) detention grade dome lamp.
   6. One (1) Intercom master speaker and microphone of each type used.

B. Spare parts shall be packaged in appropriate protective packing material.

C. Box spare parts for easy storage and clearly identify the contents of each box on all four sides of each container.

3.04 FIELD QUALITY CONTROL

A. Wattage Taps: Verify and document the tap setting of each speaker and record the level setting of each volume control station after testing is complete.

B. Intercom Station Operation: Verify and document that intercom station calls register on the appropriate TCS and that each intercom can be called from the TCS. Check that all integrated events occur as specified for each intercom actuation.

C. Audio Path: Verify and document the voice path of each intercom station to the local TCS station for clarity and volume. List the final tap setting for each intercom station after testing is complete.

D. UPS Operation: Operate the system on standby power or UPS for one hour. Place and answer an intercom station call every 60 seconds during this test. After the test is complete, record the output levels of the UPS and batteries.

E. Test Reports: Provide written test reports documenting all of the above with either a narrative for each point or a list of features noting “pass” or “fail”. Provide copies of the tests to the Engineer before requesting the Engineer to witness a functional test.

INTERCOM AND PAGING VERIFICATION AND CHECK-OUT FORM

✓ = OK

Job #
Job Name:
Panel #

FIELD TEST CODE:		**REPAIR CODE:**	
A - No status change	M -Adjust paging amp	1-SSI	Software Test By:_____ Date_____
B- No power to intercom	N -Paging reversed	2-ELECTRICIAN	
C -No audio	O -	3-IRONWORKER	Hardware Test By:_____ Date_____
D -Poor audio	P -	4-CARPENTER	
E -No CCTV call-up	Q -	5-OWNER/REP	System Test By:_____ Date_____
F -Intercom button sticks	R -	6-ENG	
G -Intercom Reversed	S -	7 -	Design Engineering By:_____ Date_____
H - Adjust intercom amp	T -	8 -	
I - Software problem	U -	9 -	Wiring By:_____ Date_____
J -Not installed	V -	10 -	
K -Paging zone failure	W -	11 -	Field Test By:_____ Date_____
L - Paging speaker failure	X -	12 -	

							ON-SITE				
ICON ID#	**ICON TYPE**	**C/U CAM. NO.**	**CCTV INTLK WITH**		**SOFT-WARE TEST**	**IC TEST**	**FIELD TEST CODE**	**REPAIR CODE**	**RE-CHECK "X"**	**FIELD CHECK OUT NOTES**	**PROBLEM RESOLVED (BY/DATE)**

END OF SECTION 275123

DIVISION 28 – ELECTRONIC SAFETY AND SECURITY

SECTION 280500 - COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Limits and scope of work under the Electronics Security Contractor Section shall be defined in these specifications.

C. Provide materials, labor, equipment and services necessary to furnish, deliver and install a completely functional integrated system.

D. All equipment and work shall comply with all applicable codes.

1.2 SUMMARY

A. The Electronic Security Contractor (ESC) shall provide all portions of the security systems and be responsible for integrating them into a system as specified.

1. The ESC shall submit an aggregate bid for Work described in the following specification sections. The ESC shall be responsible for performing the coordination required between security electronic systems and the detention equipment as well as the Electrical work. Security Electronic Systems Work required by, but not specified in, this Section includes the following:
   1) Division 27, Section 270548 “Vibration and Seismic Controls”
   2) Division 27, Section 271500 “Communications Horizontal Cabling”
   3) Division 27, Section 274113 “Cable Television System”
   4) Division 27, Section 275123 “Intercom System”
   5) Division 28, Section 280500.1 “Uninterruptible Power Source”
   6) Division 28, Section 280500.2 “ Conduit and Raceways”

(Conduit Provided by Division 26. ESC is responsible to coordinate conduit installation)

   7) Division 28, Section 280548 ”Vibration and Seismic Controls”
   8) Division 28, Section 281000 “ Fiber Optic Testing”
   9) Division 28, Section 281300 “ Access Control System”
   10) Division 28, Section 282300 “ IP Video Surveillance”
   11) Division 28, Section 283111 “Digital Addressable Fire Alarm System”
   12) Division 28, Section 284600 “Touchscreen Control Station”
   13) Division 28, Section 284600.1 “Control Matrix”
   14) Division 28, Section 284600.2 “Event Recording System”
   15) Division 28, Section 284619 “PLC Electronic Detention Monitoring and Control Systems”

2. **This project is defined as a "Design/Bid/Build" project. Approved ESC firms must base their bid on the equipment and products specified herein or approved by Addendum. Design changes or product substitutions will not be allowed. Value engineering proposals will not be considered. Substitutions on the specified software will not be approved.**

3. The ESC shall have in its employ a full time superintendent to supervise the work of this section. The superintendent's responsibility shall be to supervise and coordinate the scope of work of the ESC. The superintendent shall be at the site at all times when the work is being performed.
4. If any portion of the work listed in paragraph 1.2.A.1 above is subcontracted, the responsibility for system coordination and integration remains with the ESC.
5. The ESC shall be fully responsible for reviewing the conduit routing for the security electronic systems and devices and notify the Architect / Engineer of any modifications required prior to any conduit installation. The ESC shall meet with the Division 26 subcontractor prior to conduit installation and provide any coordination information associated with the systems and devices provided by the ESC. The ESC shall be responsible for providing a backbox schedule to the Division 26 Contractor prior to conduit installation.
6. The ESC shall be fully responsible for acquiring and paying for any and all licenses and permits required to perform their Work. If licenses are required before bidding, then the ESC shall not bid any portion of the Work until the required licenses are obtained.

B. Related Work Furnish and Installed by Others.
1. Specification section 087163 Detention Door Hardware
2. Specification section 083463 Detention Doors and Frames
3. Casework and Millwork.
4. Conduit installed by Division 26.
5. Equipment grounding system.
6. All 120/208/240 VAC branch circuits including conduit, wiring and connections from power distribution panels to terminal strips and/or receptacles in electronic control panels and/or at electronic system devices. All distribution and branch circuits described above shall be connected to the emergency power source.
7. Furnishing and installing hardware for non-security doors.

C. Manufacturer's Qualifications
1. Refer to each individual specification section for a list of acceptable manufacturers.
2. Throughout the specifications and drawings types of materials may be approved and specified by the manufacturer's name and catalog number in order to establish standards of quality and performance. If the bidder desires to substitute, he must request the Architect's approval in writing fourteen (14) days prior to bid date. Approval must be issued by written Addendum prior to bid date.

D. Electronic Components
1. Provide electronic components from manufacturers who at present have not less than ten (10) years continuous successful experience in the design and manufacture of the type products required for this project.
2. Electronic Components shall be tested and found to by a nationally recognized testing laboratory to meet nationally recognized standards or to be safe for its intended purpose.
3. Electronic Components shall be listed or recognized by the following;
   a. Factory Mutual Laboratories (FM).
   b. Underwriters Laboratories, Inc (UL).
   c. National Electrical Manufacturers Association (NEMA).

1.3 PRE-QUALIFICATION REQUIREMENTS

A. The following ESC firms are pre-approved to perform the work of this Section:

1. Accurate Controls, Ripon, WI; 920-748-6603
2. CMLRW Security, Erie, CO; 720-466-3650
3. Com-Tec Security, Inc., Appleton, WI; 920-749-2840
4. Cornerstone Detention, Decatur, Alabama 256-560-4207.
5. Metroplex, San Antonio, TX; 210-495-5245
6. Sierra Detention Systems, Brighton, CO; 303-278-6879.

Note: Approval of a firm as an ESC does not relieve the ESC from furnishing all materials from manufactures as herein specified.

1.4 SUBMITTALS

A. Submittals shall be organized into four (4) major sections as follows:

1. General data:
   a. Table of contents.
   b. Descriptive responsibility for all parties where the ESC must interface with other trades/contractors.
   c. System theory of operations that clearly defines the operating parameters of all systems being supplied.
   d. A functional systems block diagram showing single-line interconnection of all integrated systems and the major components of each system and methods of integration.
   e. Signed certification that the controls have been coordinated with the approved detention hardware submittals.
   f. Signed certification that the emergency power requirements been coordinated with the approved electrical contractor submittals.

2. Manufacturer's data sheets organized by specification section:
   a. Table of contents.
   b. Bill of material for each system listing the quantity and device model submitted.
   c. Device data sheets to be organized in the same order as equipment was specified.
   d. Provide data sheets for additional items as required at the end of each section.
   e. The data sheets shall be annotated to clearly identify only those specific models, functions, and features that are applicable to this project.

3. Calculations and schedules organized by system:
   a. Table of contents.
   b. Calculations as specified in each section.
   c. Voltage drop calculations for all circuits. Where multiple runs of the same conductor are furnished, figure worse case only. Provide certification that all other runs are shorter.
   d. Schedule of points of all electronically operated devices and their functional attributes for all systems being supplied. The schedules shall be organized by system (i.e., locking, audio, lighting, duress, etc.) and shall be formatted in alphanumeric order by architectural identification number. As a minimum for each commodity entry, the schedules shall include the following:
      1) Associated architectural number (i.e., door 108)
      2) Assigned operation number (i.e., D108)
      3) Hardware group (i.e., HW-1). This is a designation given to a standard set of complete hardware being utilized. Identify all part numbers (P/N):

4) EX IC-1 consists of:
   a) 1-5" Speaker P/NXXXX
   b) 1-Baffle P/NXXXX
   c) 4-Security Screws

4. Shop Drawings
   a. Complete list of drawings.
   b. Table listing wire and installation components to be used.
   c. Wiring diagrams for each device.
   d. Review and coordinate conduit drawings and confirm routing locations prior to installation. Provide wiring information for each device and conduit run to Division 26. Provide wire fill information along with interconnection for all security items.
   e. Touchscreen Control Station drawings/artwork that depict configuration of all control maps. Include utility and administrative screens
   f. Rack layout drawings.
   g. Control room, security electronic equipment room and MDF T/D equipment room layout floor plans and elevations. Drawings shall include dimensions indicating clearance related requirements provided by ESC.
   h. Provide riser diagram of each system indicating the location of each component and all interconnections for signal and power. At a minimum the submittal shall include risers detailing all components for the following systems: PLC, IP Video Surveillance, CATV, Intercom, Fire Alarm, and Access Control System.

B. Submittals not organized as specified shall be considered incomplete and will be rejected.

C. The ESC shall provide one set of a "draft" submittal to the Architect/Engineer as described in "A" above. All comments and changes shall be noted on the "draft" submittal and returned to the ESC at the end of the review. The ESC shall incorporate those comments and changes into the "final" submittal. The ESC shall return the "draft" submittal along with the required number of sets of the corrected submittal for final review.

D. Submittals for all security electronics sections shall be submitted at one time regardless of which firm is providing equipment or installation.

E. Unless required otherwise in Division 1, the ESC shall submit one (1) complete sets of submittal documentation for final approval. Submittals shall include items listed in "A" above. Include one (1) electronic copy.

F. The ESC must include with the draft and final submittals one (1) set of submittal information in PDF format available from Adobe at www.adobe.com. Provide a single file bookmarked for each specification section and each data sheet for easy reference. All files shall be searchable by text through Adobe Reader. The files shall be electronically transmitted through the project ftp site or the contractors ftp site. Provide submittal as follows:

1. Table of Contents
   a. List each major specification section.
   b. Each major specification section shall be subdivided into a Bill of Material for all equipment provided in that section. In each subdivision, provide a detailed list of the equipment indicating manufacturer's model number and quantity. Each model number shall act as a hyperlink to the datasheet for the listed equipment.

c. The user shall be able to navigate to the correct file through the hyperlinks under the table of contents, by manually selecting folders until they find the correction file, or a text search.

2. Horizontal Cabling
   a. Data sheets (including relays)
   b. Fiber Schedule
   c. Cable Schedule

3. Door Locking Control
   a. Programmable Logic Controller (PLC)
      i. Data sheets (including relays)
      ii. Operation manual
      iii. Programs
   b. Touchscreen Control Station
      i. Data sheet
      ii. Screen Maps
      iii. Operation Manual
      iv. Software versions and license numbers
   c. Intercom
      i. Data sheets
      ii. Operation manual
   d. Event Recording System
      i. Data sheets
      ii. Operation manual

4. IP Video System
   a. IP Video Stations and Monitors
      i. Data sheets
      ii. Operation manual
      iii. Programs
   b. Cameras
      i. Data Sheets
      ii. Operation Manual
   c. Network Storage, Switches, and Servers
      i. Data sheet
      ii. Operation Manual
      iii. Programs

5. Fire Alarm System
   a. Controls and Terminal Cabinets
      i. Data sheets
      ii. Operation manual
      iii. Programs
   b. Initiating Devices and Indicating Appliances
      i. Data Sheets
      ii. Operation Manual

6. CATV System
   a. Amplifiers and Signal Distribution
      i. Data sheets

ii. Operation manual

7. Access Control System
   a. Main Controller boards
      i. Data sheets
      ii. Operation manual
      iii. Programs
   b. Devices
      i. Readers
      ii. Door Position Switches
      iii. Request to Exit Devices
   c. Card Enrollment Station CAE
      i. Computer Station
      ii. Camera
      iii. Software

8. Miscellaneous components
   a. Conduit and Raceways coordination information.
   b. Racks and hardware
   c. Uninterruptible Power Supply
   d. Wire and Cable

9. Installation and Fabrication Drawings.

G. The submittal documents shall be updated throughout the project construction and incorporated into the Operation and Maintenance manuals.

1.5 OPERATING/MAINTENANCE MANUALS

A. ESC shall furnish three (3) copies of Operation and Maintenance Manuals for all security electronics systems furnished under this specification. These manuals shall include:

1. Instructions for the care and operation of the systems and materials.
2. Parts list to aid the Owner with ordering replacement parts.
3. As-Built conditions, **The ESC shall have a draft copy of the as-built drawings and Operating and Maintenance Manuals onsite for the final system inspection.**
4. Telephone, Fax, Address, website and instructions for contacting the appropriate personnel during the warranty period as well as for service.

B. The owner has the right to request an interactive Operation Manual in place of the printed hard copy manuals described above. The interactive manual will utilize the files described in 1.03, D above as a basis for an interactive document utilizing a web browser. All manuals, files, and data sheets would be published in format compatible with Internet Browsers equal to Microsoft Internet Explorer. Hyperlinks would link each item in a master table of contents to individual manuals, CAD drawings, and files. The ESC shall clarify with the owner the type of documentation required.

C. One (1) copy of the programming and source code of the applications software on a non-volatile media (DVD/CD or Solid State) format. This copy shall have all programmer comments, variable names, and mnemonics included.

D. Provide a disk for each panel or CPU. Provide a typed directory with all required passwords and procedures to reload software.

E. All keys, passwords, access codes, and software required to access the programming shall be furnished to the owner as part of this project. Turn over to the owner at the end of the project.

F. Furnish a digital copy of the facility's Operation and Maintenance Manual in PDF format on the ERC.

1.6 SUBSTITUTIONS

A. No substitutions of equipment or material will be permitted where specific trade names or a manufacturer is listed, unless the architect adds them by an addendum.

B. Materials and products specified by name of manufacturer or brand trade name shall be the basis of the bids received unless changed by addendum prior to the bid dates.

C. In the event a contractor wishes to use any materials or products other than those specified, he shall make a written request to the Architect, naming the proposed substitution.

D. All additional costs resulting from the use of an approved substitution shall be borne by the contractor without additional expense to the Owner.

1.7 COORDINATION

A. Coordinate work to ensure efficient and orderly installation of each part of the work. Coordinate sequencing and scheduling of electronic work. Secure time commitments for performing critical construction activities from separate entities responsible the work.

B. Coordinate selection of electronic products for compatibility.

C. Coordinate installation of anchorages and embedment’s for electronic work.

D. Coordinate temporary facilities required for electronic work.

E. Coordinate protection of installed electronic work.

F. Coordinate preparation of Project Record Documents for electronic work and integrate information from entities responsible for electronic work to form one combined record.

G. Coordinate preparation of operation and maintenance manuals for electronic work and integrate information from entities responsible for electronic work to form one combined record.

H. Coordination Meetings: Conduct coordination meetings specifically for electronic work at regular intervals.

1.8 WARRANTY

A. The ESC shall warrant the systems and equipment furnished by each under this Section to be free from defects in material and workmanship for a period of one (1) year after substantial completion.

B. The ESC must have full-time employees trained in and devoted to the maintenance and repair of systems and equipment furnished.

C. Additional Programming: The ESC shall include all associated costs for a three (3) month post occupancy system walk through with owner and shall allow for eighty (80) hours of site specific program changes to the system.

D. The contractor shall furnish and install all firmware upgrades and software patches released during the warranty period for all software furnished and installed as part of the Security Electronics systems. Firmware and software fixes shall be installed as they are released for both the video management system and the door locking control system.

E. The contractor shall complete a field report after each trip and have it signed by the facility leaving a copy with the facility.

F. Contractor shall certify in the Operation and Maintenance manual as well as in each field warranty report that the firmware, software, and hardware are compatible and have been tested as a system for both the video management system and the door locking control system.

PART 2 - PRODUCTS

2.1 SECURITY SCREWS

A. Equipment: All security equipment specified within divisions 27/28 shall have stainless steel torx-head with center-pin security screws. Such areas include but are not limited to corridors, dayrooms, cells, multipurpose rooms, medical, visitation areas, kitchens, commissary, and laundry.

B. Alternatives: Additional means of locking or securing devices are as indicated in each section.

2.2 SECURITY COVERS

A. Equipment: All security equipment specified within divisions 27/28 located in youth areas within reach of youths, which are not of detention grade because of code requirements, or application shall be protected with security covers. Provide covers sized to completely surround the device with out substantially degrading the function.

B. Alternatives: Other options for protecting devices are as indicated in each section or shown on plan details and elevations.

PART 3 - EXECUTION

3.1 FACTORY ASSESSMENT DEMONSTRATION

A. The ESC shall provide a factory assessment test and demonstration for the security electronic system. This shall be at the ESC's fabrication shop. The ESC shall notify both the security consultant and owner four (4) weeks in advance of the test being scheduled. **The ESC shall cover all travel expenses for one architect, one engineer, and two of the owner's representatives to be present.**

1. Provide the all of the TCS stations that will be installed in Central Control and in the housing buildings. This will include the intercom microphone, video spot and sequence monitors. All control functions shall be demonstrated. At least one field device of each type installed shall be active at the time of the test.
2. At a minimum provide an intercom and duress station. Simulate locks with lamps or LED's. Simulate door position switches with commercial DPS or switch.
3. Task group assignment will need to be operational. Demonstrate all utility functions and emergency release. Demonstrate the transfer of task groups between stations.
4. All alarms shall be functional. Examples are the duress pushbutton, UPS, network failure and door alarms.
5. Provide all IP Video monitors to be installed in the facility and connect two cameras of each type in each task group. One camera shall call up when answering a door intercom and the other shall be for general supervision.
6. Demonstrate the IP Camera system and recording call up. Generate at least 5 days of recording on the connected cameras for use in demonstration. Demonstrate three levels of recording quality.
7. Demonstrate the card access system. Provide the Card Access enrollment station.
8. Provide the intercom recording stations, and demonstrate the recording of intercoms.
9. The factory test shall include the ERC unit and printer. Demonstrate the generation of reports and provide printouts for review.
10. One week before the factory demonstration, submit to the engineer a detailed schedule and agenda of the test for review and comment.
11. The listed above is a minimal that can be provided. It is preferred to have the entire electronic system operational as one system if possible.

B. If for any reason an additional FAT is required because the Work is incomplete or if any portion of the system fails to function as designed the ESC shall be responsible for paying for the time and expenses for the engineer and owner to re-schedule and re-test the Work. This cost shall include time and expense for each individual of the Security Consulting firm required to return for the re-test. The cost shall be a minimum of $5000.00 per individual occurrence. This cost will include travel time, inspection time and travel expenses. This amount must be paid **prior** to re-scheduling the inspection.

3.2 INSTALLATION

A. Listing: All wiring and raceways shall be listed for the intended installation and installed in strict accordance with the California Electric Code as required by the conditions of where it is installed.

B. Abandoned Wire: All wiring not energized shall be terminated at both ends and labeled for future use. There shall be no abandoned wire.

C. All wiring shall be fully terminated in all racks and cabinets on **screw type terminals**. All wire is to be landed on screw terminal units of size, amperage rating, material, type, and class suitable for service indicated.

D. All wiring/cabling shall be labeled with the system type and the device ID at each end. All labeling shall be by mechanical means. The label shall be generated by a Brady I.D. Plus Pro Printer or equal, and utilize a Brady part# WML-511-292 label or equal. The label used should allow for the clear part of the label to overlap and protect the printed portion of the label from

being exposed to damage and/or being rubbed off over time. Hand written labels are not permitted.

E. All wiring outside of equipment rooms is to be in conduit. Coordinate conduit routing with Division 26.

F. Seismic: The entire system shall be installed to meet the seismic requirements for the area.

3.3 INSPECTIONS AND TESTING

A. The General Contractor and ESC shall be responsible for issuing a letter to the Architect and R&N Systems Design, LLC confirming that the work is complete and ready for inspection and testing. If the project is completed in phases, a letter will be submitted for each phase to be inspected. As an attachment to the letter confirming the work is “complete” and ready for inspection, the ESC must attach a self-generated “field test” report for each device which confirms in detail that the ESC has performed their own inspection and test prior to the inspection by the Architect / Consultant.

B. The inspection shall include Systems, Subsystems, Equipment, and Components. Where these terms are used together or separately, they shall be referred to as “the system”. The ESC shall be prepared to test every point for each system.

C. If additional inspections are required because the Work is incomplete at the time of the scheduled inspection or if any portion of the system fails to function as designed the ESC shall be responsible for paying for the time and expenses for the Architect and Security Consultant to re-schedule and re-inspect the Work. This cost shall include time and expense for each individual of the Security Consulting firm required for the re-inspection. The cost shall be a minimum of $5000.00 per individual occurrence. This cost will include travel time, inspection time and travel expenses. This amount must be paid **prior** to re-scheduling the inspection.

D. The Superintendent and Project Manager shall be present and assist in the inspection / testing of the Work.

E. Substantial completion will not be granted by the engineer until the system is installed and functioning to the Engineer's satisfaction and in accordance with the contract documents. The Engineer has the right to withhold the granting of substantial completion and schedule additional inspection if the system is not installed and functioning in accordance with the contract documents.

3.4 SHAKEDOWN PERIOD

A. Coordinate with the Owner and Construction Manager/General Contractor to establish a shakedown period for the security systems. This shakedown period shall not begin until after “substantial completion” is issued. The shakedown period shall be a minimum of 15 days. If functionality or programming problems occur during the first 15 day, the shakedown period shall be extended for a minimum of two weeks after the systems are functioning dependably.

B. ESC shall be responsible for providing a full time technician / programmer at the facility at all times during the shakedown time period to support operation of the facility by the Owner’s staff.

C. Maintain a detailed log of all anomalies, malfunction and repairs encountered during the shakedown period. Submit log to the Architect for assessment at the conclusion of the shakedown period.

D. Additional training of Owner's staff may occur during the shakedown period.

3.5 SPARE PARTS

A. The ESC shall deliver all spare parts at the completion of the project. The spare parts shall be clearly marked as to content and packaged for ease of handling by one (1) person without the use of forklifts or other equipment. The ESC shall obtain a signature from the owner's representative receiving the spare parts.

B. The ESC shall furnish the parts described in each subsection of the specifications.

C. Furnish 2 spare security covers of each type installed.

3.6 TRAINING

A. The ESC shall provide, without additional cost to the owner, training in the operation of the security systems provided. The representatives shall train the Owner's personnel in operation, repair, and upkeep of each system.

B. The ESC shall be responsible for notifying the architect three (3) weeks prior to substantial completion of the total security system that training is scheduled. The ESC will coordinate the number to be trained with the owner's representative.

C. The length of training is directly related to the size and complexity of the detention facility, but in no case shall the security electronics system training be less than three (3) days.

D. Course Structure

1. The ESC shall prepare and present to the Architect a detailed course outline that specifies each major training module to be covered. The training program on the security equipment shall include the sequences and instructions for proper use and maintenance of all hardware, locking devices, control, and monitoring systems. The material shall be presented in simple layman's terminology, describe and demonstrate all step-by-step physical operations necessary for proper operation, and detail necessary equipment adjustments. At the time of training, each trainer shall present to the trainees detailed outlines of each training module to be covered and the specific skills and knowledge which the trainee is expected to master within each training module.
2. At a minimum, the training program shall be subdivided into the following training modules:
    a. Operation of the Security System.
    b. Troubleshooting, General Maintenance, Equipment Adjustments, Repair and Replacement of Security System Components.
    c. Operator Controls.
    d. Descriptive modules organized by specification section.

E. The ESC shall videotape each training module. The videotaping does not have to include individual student practice. The ESC in preparing the videotape shall structure it for easy reference by the facility's training officer for future use. Furnish digital copies of the facility training videos in a Windows Media file format (.wmv or equal) on the ERC. Files shall be easily viewable on the ERC's media player for training staff.

F. Training Certification

1. Each facility employee shall receive at the conclusion of the security systems training program a certificate certifying his attendance of the total session or portion thereof.
2. ESC shall maintain attendance records of each class.

G. Operation and Maintenance (O&M) manuals:
1. Utilize the Operation and Maintenance manuals prepared for the facility for the training.
2. Review all procedures in the Operation and Maintenance manuals.

H. In addition to the training requirements listed above the ESC shall include all associated cost to provide additional onsite owner training following substantial completion. The additional training shall occur at the three (3) months periods and shall cover topics as referenced above. Coordinate this additional training with the owner.

END OF SECTION 280500

STATEMENT OF QUALIFICATIONS

Electronically Submit To:

SUBMITTED BY:	Corporation	☐
NAME:	Partnership	☐
ADDRESS:	Individual	☐
TELEPHONE NO.:	Joint Venture	☐
FAX NO.:	Other	☐
PRINCIPAL OFFICE:		

RESPONSE MEDIUM: Bind all files and information submitted into a single PDF searchable for keywords. Files less than 5 Megabytes can be emailed. Larger files must be located on an ftp or Box site with an emailed link.

TYPE OF WORK:
Electronic Security Contractor (ESC): The ESC shall be responsible for providing the custom fabricated equipment, programming, and systems integration for all security electronic systems as specified. The ESC shall be responsible for testing and coordinating the final configurations of the system with the owner's representative. Final test and confirmation of proper function must be made by the ESC. The Scope of Work for this contractor will be defined in the drawings and specifications prepared by DLR Group and R&N Systems Design, LLC.

The ESC shall furnish at least 5 project references for correctional facilities of similar size and scope. ESC may list projects that are completed or actively under construction. Do not list projects completed before 2009. Please specify scope of work for each job reference provided.

Where there is not sufficient space in the form for a complete answer, insert the words "Refer to attached sheet" and add a page copying the referenced question and paragraph number at the top of the page. Each page shall reference one question for clarity.

1. ORGANIZATION

1.1 How many years has your organization been in business as an Electronic Security Contractor (ESC)?

1.2 How many years has your organization been in business under its present business name?

1.2.1 Under what other or former names has your organization operated? (Attach additional details with reference to this paragraph number if required.)

Year	Name of Organization	Principal Owners

1.3 If your organization is a corporation, answer the following:

1.3.1 Date of incorporation:

1.3.2 State of incorporation:

1.3.3 President's name:

1.3.4 Vice-president's name(s):

1.3.5 Secretary's name:

1.3.6 Treasurer's name:

1.3.7 ESOP Companies (list Board of Directors and Trustee)

1.4 If your organization is a partnership, answer the following:

1.4.1 Date of organization:

1.4.2 Type of partnership (if applicable):

1.4.3 Name(s) of general partner(s):

1.5 If your organization is individually owned, answer the following:

1.5.1 Date of organization:

1.5.2 Name of owner:

1.6 If the form of your organization is other than those listed above, describe it and name the principals or owner: (Attach additional details with reference to this paragraph number if required.)

2. LICENSING

2.1 List jurisdictions and trade categories in which your organization is legally qualified to do business, and indicate registration or license numbers, if applicable.

2.2 List license information for the State of California.

2.3 List jurisdictions in which your organization's partnership or trade name is filed.

3. EXPERIENCE

Check (√) in the categories of work that your organization normally performs with its own forces.

Manufacture	Supply	Installation	SECURITY ELECTRONICS
			Access Control System
			Control Processing Equipment & Relay Panels
			Graphic Annunciated Door Control Panel Systems
			Computer Control Stations
			Hardwired Logic Control Systems
			PLC Control Systems
			Intercommunication Systems
			Fire Alarm System
			Lightning/Surge Protection
			Nurse Call System
			Perimeter Detection Systems
			Personal Alarm/Duress System
			Vehicle Detection
			IP Video Management System
			Video Visitation Systems
			Video Arraignment Systems
			Other (Describe)

3.1 List 5 construction projects for correctional facilities that have similar size and scope. Projects can be either completed or actively under construction. Do not list projects completed before 2009. (Attach additional pages giving details with reference to this paragraph number.) Provide the following:

1. Name of project.

2. Name of Owner. (Provide contact name and phone number.)

3. Name of Architect / Engineer. (Provide contact name and phone number.)

4. Name of General Contractor (If applicable) (Provide contact name and phone number.)

5. Contract Amount.

6. Occupancy.

7. List the year the project was/will be completed.

8. List the projects delivery method: (Design-Bid-Build, Design-Build)

3.2 In addition to the projects above, list construction projects the organization currently has in progress with security electronic subcontracts for correctional facilities. Provide the following.

1. Name of project.

2. Name of Owner. (Provide contact name and phone number.)

3. Name of Architect / Engineer. (Provide contact name and phone number.)

4. Name of General Contractor (If applicable) (Provide contact name and phone number.)

5. Contract Amount.

6. Occupancy.

7. List the anticipated year the project will be completed.

8. List the project delivery method: (Design-Bid-Build, Design-Build)

3.3 State annual amount of security electronic work performed during the past five years:
2010:

2011:

2012:

2013:

2014:

3.4 State total worth of security electronic work currently under contract and in progress as of September 1, 2015.

3.5 Claims and Suits. List separately for each category listed above. (If the answer to any of the questions below is yes, please attach details with reference to the paragraph number).

3.6.1 Has your organization ever failed to complete any work awarded to it?

3.6.2 Are there any judgments, claims, arbitration proceedings or suits pending or outstanding against your organization or its officers?

3.6.3 Has your organization filed any law suits or requested arbitration with regard to construction contracts within the last five years?

3.6 Within the last five years, has any officer or principal of your organization ever been an officer or principal in another organization when it failed to complete a construction contract? (If the answer is yes, please attach details.)

4. PERSONNEL

4.1 Provide an Attachment referencing this paragraph number, providing the following:

4.1.1 Specifically designate the superintendent that will be assigned to this project. This person must have experience in the past 5 years with correctional facilities. Provide a brief resume of this person, highlighting their experience.

4.2 Provide an Attachment referencing this paragraph number, provide the following:

4.2.1 Specifically designate the senior project manager that will be assigned to this project. This person must have experience in the past 5 years with correctional facilities. Provide a brief resume of this person, highlighting their experience.

5. REFERENCES

5.1 Architect/Engineer References (list three):

5.1.1 Name:
Contact:
Address:
Telephone:

5.1.2 Name:
Contact:
Address:
Telephone:

5.1.3 Name:
Contact:
Address:
Telephone:

5.2 Owner References (list three):

5.2.1 Name:
Address:
Telephone:

5.2.2 Name:
Address:
Telephone:

5.2.3 Name:
Address:
Telephone:

6. SURETY

6.1 Name of bonding company:

6.2 Name and address of agent:

6.3 Provide a letter from your bonding company that states your current bonding capacity:

7. FINANCING

7.1 Bankruptcy

7.1.1 Has your organization filed bankruptcy in the past five (5) years?

If yes, list the year in which bankruptcy was filed.

7.1.2 Has your organization under a previous name or other organizations that you have acquired ever filed bankruptcy?

If yes, list the organization's name and the year in which bankruptcy was filed.

7.1.3 Have any of the key personnel managing the scope of work defined in this qualification been a member of or employed by an entity that filed bankruptcy in the past five years?

If yes, list the organization's name and the year in which bankruptcy was filed.

8. MANUFACTURER CERTIFICATION:

8.1 Along with the above required documents, the ESC shall submit any written letters or certifications from equipment manufacturers stating that individual field technicians employed by the ESC have been approved as installers.

Submission Due Date: Electronic PDF must be received by 5:00 pm central time 10 business days before the bid date.
Email file or link to Frank Niedzwiedz - frankn@rnsystemsdesign.com.

The Undersigned certifies that the information provided herein is true and sufficiently complete so as not to be misleading.

SIGNATURE

Dated this _____ day of _____2015.

Name of Organization:_____

(Signature) By: _____

Title: _____

(Printed) _____ certifies that the information provided herein is true and sufficiently complete so as not to be misleading.

Subscribed and sworn before me this _____ day of _____2015

Notary Public:_____

(Seal)

My Commission Expires:

SECTION 280500.1 - UNINTERRUPTIBLE POWER SOURCE

PART 1 - GENERAL

1.1 SUMMARY

A. Scope of Work: Provide Uninterruptible Power Supply (UPS) units to supply 120 volt AC power for all, intercom masters, relay boards, locking controls systems, PLC equipment, IP video equipment, access control systems, video arraignment/visitation systems, and any other security electronics not provided with batteries. All security systems components are required to have a battery backup or be supplied with UPS power.

B. The ESC is responsible for furnishing all of the UPS system components that are required for this project. This is to include UPS units, battery cabinets, and bypass switches. Division 26 is to furnish the distribution panels, power source equipment, distribution feeders, and receptacles. The ESC is to coordinate the installation of the UPS system components as well as the 120 VAC UPS power distribution panel with Division 26.

C. The ESC shall confirm that the security electronics systems are powered from an emergency power source.

D. Refer to SE drawings for UPS location, sizing, and additional information.

E. The ESC as defined in Section 280500 Common Work Results for Electronic Safety and Security shall be responsible for providing and coordinating this system.

1.2 SYSTEM DESCRIPTION

A. System Capacity: Size Each UPS system appropriately so that it shall independently deliver power to the connected load for not less than **one (1) hour** in the event of failure of the normal and emergency power source.

B. The individual UPS sizes indicated on the SE drawings are the minimum sizes allowed at each location.

C. Growth capacity: Size units for a minimum growth capacity of 25% at each UPS.

D. Provide UPS system components for new security equipment at the following equipment room locations:
   1. 3 KVA unit in SEC/ELECT room 130 in building 1A.
   2. 3 KVA unit in SEC/ELECT room 130 in building 1B.
   3. 3 KVA unit in SEC/ELECT room 132 in building 2.
   4. 15 KVA unit in SEC/ELECT room 162 in building 4.
   5. 3 KVA unit in TEL/IDF/SEC room 116 in building 5.
   6. 3 KVA unit in SEC/ELECT room 121 in building 6.
   7. 3 KVA unit in Storage room 111 in building 7. (BASE BID)
   8. ADD ALTERNATE 3 KVA unit in SEC/ELECT room 118 in building 3.

E. In addition to SEC rooms, furnish and install UPS system 120 vac power receptacles for new security equipment at the following locations:
   1. Officer Station 106 in Building 1A
   2. Officer Station 106 in Building 1B
   3. Officer Station 109 in Building 2
   4. Central Control Room 102 in Building 4
   5. ProceESCng 110 in Building 4
   6. Pole Mounted Sited Cameras

   Refer to Power Risers on SE6.0.4 & SE6.0.5 for more information.

1.3 SUBMITTALS

A. Basic Submittals: Provide submittals as required by the General Conditions.

B. Special Submittal Requirements: In addition to the contract requirements for submittals, provide comprehensive UPS load calculations for each UPS.

1.4 SYSTEMS INTEGRATION

A. Integration: Integrate the UPS system with the PLC system to annunciate and log alarms associated with the UPS in Central Control only.
   1. Low voltage.
   2. Low battery.
   3. High voltage.
   4. Inverter power on.
   5. Inverter power off.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Eaton Powerware Division

B. Sola Electric

C. American Power Conversion (APC), only for smaller units under 2200VA.

2.2 MATERIAL / EQUIPMENT

A. UPS: Provide Powerware 9355 model UPS (or equal) sized accordingly in Building 4. Provide features as follows:
   1. Nominal Inpute Voltage of 208V – 4 wire – three phase.
   2. Operating temperature is from 0° C to 40° C with an R.H. of 5% to 95% without condensation.
   3. Overload capacity should be 150% surge and 125% for 10 minutes.
   4. Communication shall be through an RS-232 serial port (DB-9).
   5. Continuous, no-break power during a complete power outage or momentary power interruption.
   6. Hardwired connections from the primary power source to the unit. Hardwired connections from the unit to the UPS distribution panel.

7. UPS and Battery cabinets shall have rollers as to ease with maintenance and to allow for access to the rear and sides of each unit. **Provide hard wire connections using seal tight type conduit and compreESCon fittings to all UPS system equipment.**

B. Rack mounted UPS: Provide Eaton 5P3000RT (or equal) rack mounted UPS in SEC Racks in all buildings except Building 4 Administration.

C. Bypass Switch: Provide an external bypass isolation switch arrangement to bypass UPS and place load on utility power for maintenance of UPS unit. Switch shall be a Make Before Break (MBB) type unit. No other function will be acceptable.

D. Batteries: The batteries shall be standard sealed lead-acid type, especially designed for UPS use. Furnish the required number of batteries to supply power to the connected load for a period of one (1) hour. The complete system (batteries and UPS system) shall be furnished and guaranteed by the same manufacturer.

E. KVA: Size the UPS and batteries to power all the Security Electronics equipment for **one (1) hour**. The UPS sizes indicated on the plans are minimums that must be provided to allow for owner additions.

F. Surge Suppressor: Furnish and install an Eaton PTE080 surge suppressor (or equal) for monitoring input power to UPS.

PART 3 - EXECUTION

3.1 COORDINATION

A. Preliminary Examination: Coordinate all required distribution panel boards, wiring, and circuit breakers with Division 26.

B. ESC shall provide a spreadsheet listing the ESC's power requirements to the engineer and Division 26. This spreadsheet shall detail at a minimum, the amount, size, and location of power circuits in each room where UPS power is required. The spreadsheet shall include the location where each circuit is terminated and type of outlet required.

C. Construction Examination: Examine the ongoing construction and coordinate all equipment for proper installation allowing for maintenance access to UPS batteries.

D. Structural Examination: Examine locations for UPS placement to ensure the underlying structure will support the UPS and associated battery cabinets to be installed.

3.2 INSTALLATION

A. Installation: Install all UPS units following manufacturer’s recommendations and instructions in locations indicated on the plans. UPS units shall fit in the space allowed. All UPS equipment locations shall be identified clearly on the submitted drawings. Once reviewed deviations are unacceptable.

B. Connections: Connect all security/detention electronics equipment to the UPS power system. Provide sufficient electrical separation and transient suppreESCon to prevent lock actuation and power fluctuations from affecting any electronic control systems.

C. Listing: All wiring and raceways shall be listed for the intended installation and installed in strict accordance with the California Electric Code as required by the conditions of where it is stalled. This includes but is not limited to ratings for riser, plenum, or wet installations.

D. The ESC shall have the UPS manufacturer's representative field certify that the installation is acceptable and as per manufacturers specifications prior to requesting final inspection. Provide written documentation to include the manufacturer's field report with final testing reports. Include these documents with the project O&M manuals.

E. Seismic: The entire system shall be installed to meet the seismic requirements for the area.

3.3 TRAINING

A. The ESC shall provide without additional cost to the owner representatives specially trained in the operation of UPS systems provided. The representatives shall train the Owner's personnel in operation, repair, and upkeep of the UPS and custom relay cabinets.

B. The ESC shall be responsible for notifying the architect five (5) weeks prior to substantial completion of the total security system that training is scheduled. The ESC will coordinate the number to be trained with the owner's representative.

C. The length of training shall be at least four hours long and be presented to all shifts.

D. Course Structure
   1. The ESC shall prepare and present to the Architect a detailed course outline that specifies each major training module to be covered. The training program on the security equipment shall include the sequences and instructions for proper use and maintenance of all hardware, locking devices, control and monitoring systems and panels. The material content shall be in simple layman's terminology, describe and demonstrate all step-by-step physical operations necessary for proper operation and necessary equipment adjustments. At the time of training, each trainer shall present to the trainees detailed outlines of each training module to be covered and the specific skills and knowledge which the trainee is expected to master within each training module.
   2. At a minimum the training program shall be subdivided into the following training modules:
      a. Operation of the Security System.
      b. Troubleshooting, General Maintenance, Equipment Adjustments, Repair and Replacement of Security System Components.
      c. Operator Controls.
      d. Descriptive modules organized by specification section.
      e. Review of Operation and Maintenance Manuals.
      f. Review of all contact telephone numbers.
      g. Review of all warranties.

E. The ESC shall record each training module. The recording does not have to include individual student practice. The ESC in preparing the recording shall structure it for easy

reference by the facility's training officer for future use. Furnish to the owner DVD's or tape as required by the owner.

F. Training Certification
1. Each facility employee shall receive at the conclusion of the security systems training program a certificate certifying his attendance of the total seESCon or portion thereof.
2. ESC shall maintain attendance records of each class.

G. In addition to the training requirements listed above the ESC shall include all associated cost to provide additional onsite owner training following substantial completion. The additional training shall occur at the three (3) months periods and shall cover topics as referenced in paragraph "D" above. Coordinate this additional training with the owner.

3.4 SPARE PARTS

A. Furnish to the owner one spare parts kit as recommended by the manufacturer for each type of UPS installed on this project.

B. Spare parts shall be packaged in appropriate protective packing material.

C. Box spare parts for easy storage and clearly identify the contents of each box on all four sides of each container.

3.5 FIELD QUALITY CONTROL

A. Verify and document that each UPS is supplied with properly sized breaker. Verify and document that all alarms are annunciated both visually and audibly at each UPS, and at affected control stations.

B. Provide written test reports documenting all of the above function and features.

UPS VERIFICATION AND CHECK-OUT FORM

✓ = OK

Job #
Job Name:
Panel #

FIELD TEST CODE:		**REPAIR CODE:**	
A - No status change	M -	1-SSI	Software Test By:_____ Date_____
B - No power UPS	N -	2-ELECTRICIAN	
C - Verify breaker size	O -	3-IRONWORKER	Hardware Test By:_____ Date_____
D - No alarm locally	P -	4-CARPENTER	
E - No alarm CCS	Q -	5-OWNER/REP	System Test By:_____ Date_____
F - No emergency generator	R -	6-ENG	
G - No power transfer	S -	7 -	Design Engineering By:_____ Date_____
H - By Pass switch failure	T -	8 -	
I - Software problem	U -	9 -	Wiring By:_____ Date_____
J - Not installed	V -	10 -	
K -	W -	11 -	Field Test By:_____ Date_____
L -	X -	12 -	

							ON-SITE				
ICON ID#	**ICON TYPE**	**UPS NO.**	**UPS KVA**		**SOFT-WARE TEST**	**UPS TEST**	**FIELD TEST CODE**	**REPAIR CODE**	**RE-CHECK "X"**	**FIELD CHECK OUT NOTES**	**PROBLEM RESOLVED (BY/DATE)**

END OF SECTION 280500.1

SECTION 28 0500.2 - CONDUIT AND RACEWAYS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. All raceway shall be supported in accordance with ASCE 7 Chapter 13.

C. Division 26 is to furnish and install the conduit and raceway system. The ESC, as defined in Section 280500 General Conditions, shall be responsible for coordinating the conduit and raceway system with Division 26.

1.2 SYSTEM DESCRIPTION

A. Conduit: Furnish and install a complete conduit system for ESC equipment. Fully coordinate the installation of conduit system with other trades and the general contractor. All conduit installed in any pre-cast panels will be coordinated with the pre-cast contractor prior to manufacture of panel. Conduit system as shown on the drawings is for reference only. Any changes to the conduit System required to install ESC equipment as specified and APPROVED shall be the responsibility of the ESC. The ESC shall acknowledge in writing the approved conduit routing and size.

B. Pull Boxes: Coordinate the installation of all pull boxes and junction boxes required for the installation of conductors for all ESC equipment.

C. Outlet Boxes: Outlet boxes shall be of the physical size for the device to be mounted therein. Coordinate outlet boxes with equipment.

D. All conduit and security electronics raceways shall be installed as described in the California Electric Code.

E. Electrical boxes with serviceable knockouts are not allowed in accessible areas.

1.3 SUBMITTALS

A. Provide basic submittals as required by Division 27/28 General Conditions and by the General contract requirements.

B. Submit license of master electrician who will supervise all conduit installation.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Carlon

B. Allied

C. Hubbell

D. Appleton

E. Thomas and Betts

F. Steel City

G. Raco Steel Products

H. Quazite

2.2 MATERIAL/EQUIPMENT

A. Conduit: The following are standards to be used when selecting the proper conduit to install.
   1. All conduit shall be listed and labeled by Underwriters Laboratories for use as raceway system for electrical conductors.
   2. Rigid galvanized conduit shall comply with UL Standard UL 6 and ANSI standard C-80.1.
   3. Intermediate metallic conduit shall comply with UL Standard UL 1242.
   4. Electric Metallic Tubing shall comply with UL Standard UL 797 and ANSI Standard C-80.3.
   5. Rigid Non-metallic electrical conduit shall comply with UL standard UL 651.

B. Pull Box: The following are standards to be used when selecting the proper type of pull boxes to install.
   1. Pull boxes and junction boxes shall be UL listed and labeled.
   2. Dimension of pull boxes and junction boxes shall not be less than those dimensions required by the California Electrical Code, 2011 Edition, Article 314 for the number, size, and position of conduits entering the box.

C. Outlet Box: All outlet boxes shall be UL listed.

D. Enclosed Metal Wire Way:
   1. Ladder-type tray shall consist of rungs spaced 9” apart with widths as indicated on the plans. Remove all burrs and sharp edges from assembled tray.
   2. Bend radium shall be 12” or larger.
   3. Loading depth shall be 3- inches.
   4. Load rating shall be NEMA 8C – 8 foot spacing, 75 pounds per foot.
   5. Furnish and install all mounting accessories and related hardware as required for a complete installation.
   6. Shall meet the requirements of ASCE 7 for seismic installations.

E. In-ground hand-hole enclosure:
   1. Provide security bolts to attach top, Tamper Resistant Penta-Head bolt, stainless steel.
   2. Furnish and install enclosure size as required by the number of conduit entering and leaving the enclosure.
   3. Enclosure shall be ANSI TIER rating at 22.
   4. Lid shall be ANSI TIER rating at 22.

F. Innerduct: Smooth wall 1” ASTM D1248 Polyethlene plastic molding and extrusion material that meets ASTM D3035 dimensional requirements.

1. Innerduct shall be secured to wall with D-ring or similar strapping method.
2. Innerduct containing fiber shall terminate in LIU, trough, cabinet, or wire tray.

PART 3 - EXECUTION

3.1 CONDUIT INSTALLATION: CONDUITS SHALL BE APPROPRIATE FOR THE INTENDED INSTALLATION.

A. Concrete: Conduits installed within concrete wall panels which are in direct contact with grade or exposed where youths have direct access shall be galvanized rigid steel (GRS) or intermediate metal conduit (IMC).

B. Security electronic and communication conduit shall NOT be installed within the concrete floor slab. All security electronic and communication conduit shall be installed under the concrete floor slab.

C. Roof: Conduits which penetrate the roof structure shall be galvanized rigid steel (GRS) or intermediate metal conduit (IMC). Seal all penetrations.

D. Earth: Conduits installed in direct contact with the earth shall be Schedule 40, heavy wall PVC.

E. EMT: All other conduit, unless excluded herein, not permitted by the California Electrical Code, or otherwise indicated on the drawings, shall be electrical metallic tubing (EMT).
   1. All EMT fittings are to be steel compression type.
   2. DO NOT use EMT set screw fittings.

F. Different Conduit Types: Conduit types shall not be mixed indiscriminately with other types in the same run, unless specified herein or required by the CEC.

G. Flexible Conduit: Use flexible conduit when required for connections to extension arm mounted adjustable cameras.
   1. Flexible conduit used when required for connection of fixed cameras shall not exceed 18 inches in length. Cameras in youth housings shall not be connected with flexible conduit.
   2. Maintain ground continuity through flexible conduit with green equipment grounding conductor. Do not use conduit for ground continuity.
   3. Liquid tight conduit shall be used to connect equipment in the kitchen area, laundry area, exterior installations, below access floors connecting data processing and other equipment.
   4. All conduits installed exposed from the finished floor to a minimum height of ten feet above the floor shall be galvanized rigid steel (GRS). **Exposed conduit below 10 feet in youth areas is not allowed.**

H. Below Grade Raceway Installations: In addition to meeting the requirements above, conduits, under grade shall also conform to the following:
   1. Direct Burial Conduit
      a. Install top of conduit 24 inches minimum below finished grade.
      b. Install top of conduit six inches minimum below bottom of building slab.
      c. Install top of conduit 30 inches minimum below grade, below roads and any other paved surfaces.

d. Where transition is made from below grade PVC installation to a metallic conduit system above grade or slab, make transition with rigid galvanized elbow and extend through slab or above grade with galvanized rigid steel conduit. For corrosion protection, where the elbow penetrates surface, wrap with vinyl all-weather electrical tape or coat with bituminous asphaltic compound, for 6 inches above and below concrete surface.
e. Install conduit marker tape 6” above all buried conduit.

I. Raceway Installations In Concrete: In addition to meeting the requirements above, conduits in concrete shall also conform to the following:
1. Conduit shall be run following the most direct route between two points.
2. Conduit shall not be installed in concrete wall panels which is less than three inches thick or where the outside conduit diameter is larger than 1/3 of the concrete thickness.
3. Conduits shall not be installed within shear walls unless specifically indicated on the drawings. Conduits shall not be run directly below and parallel with load bearing walls.
4. Protect each metallic conduit installed 1.5 inch and smaller passing through a concrete slab against corrosion where conduit enters and leaves concrete by wrapping conduit with vinyl all-weather electrical tape or coat with bituminous asphaltic compound.
5. The maximum projection of conduit stub-up and bushing above slab shall be three inches.
6. Protect all conduits entering and leaving concrete floor slabs from physical damage during construction.
7. Provide expansion fittings for all conduits runs exceeding 200 feet or for conduits passing through building expansion joints.
8. Seal all penetrations through fire and smoke barriers in such a way as to maintain the fire and smoke ratings.
9. Install pull string in all raceways in concrete as each conduit run is completed.

J. Concealed, above Ceilings, surface mounted and exposed Installations:
1. Conduit shall be run parallel or at right angles to existing walls, ceilings, and structural members.
2. Support conduits at intervals not exceeding ten (10) feet and within three (3) feet of each outlet, junction box, cabinet or fitting for all ceiling and installations above ten (10) feet.
3. Attach individual conduits to structural steel members with beam conduit clamps and to non-metallic structural members with one-hole conduit straps. Exposed conduits suspended from structural members shall be installed with hangar rods and conduit clamp assemblies. Multiple conduits in the same run shall be supported by trapeze type supports suspended from the structure. Do not attach conduits to ceiling suspension system channels or suspension wires. All installations must meet project seismic requirements.
4. Attach feeder conduits larger than one (1) inch diameter to the building structure on intervals not to exceed ten (10) feet. Attach conduit with conduit beam clamps, one (1) hole conduit straps or trapeze type support in accordance with support systems described for branch circuit conduits.
5. Conduit support fastening devices.
a. Anchors for solid masonry and concrete shall be self-drilling expansion shields, insert type expansion shield, or lead shields with machine bolts.
b. Fasten support device to wood with wood screws. Nails are not acceptable.
c. Fasten support device to hollow masonry with toggle bolts.
d. Fasten support device to steel with machine screws with bolts and beam clamps.
6. Exposed conduits shall be painted, see painting section of the specifications.
7. Where conduits must pass through structural members, obtain approval of location and size of hole prior to drilling from Architect.

8. Install conduit sleeves in slabs where conduits 2.0 inch and larger pass through. Sleeves shall extend one (1) inch minimum above finished slab. Seal all spare sleeves and between conduits within sleeves to maintain fire rating, to make watertight, and to make smoke-tight.
9. Install all conduits or sleeves penetrating rated fire walls or fire floors to maintain fire rating of wall or floor.
10. Conduits rigidly secured to building structure on opposite sides of a building expansion joint shall be provided with an expansion and deflection coupling. In lieu of an expansion coupling, conduits 2-1/2 inches and smaller may be provided with junction boxes on both sides of the expansion joint connected by 15 inches of slack flexible conduit with bonding jumper.

K. Exposed Raceway at youth accessible areas mounted below ten (10) feet.
1. Do not install exposed conduit systems in youth housing area or other areas normally accessible to youths unless such installations are specifically indicated on the drawings. Where exposed conduit is indicated on the drawings, all conduits shall be rigid metal and all outlet boxes shall be cast metal type with threaded hubs.
2. Install conduits flat against wall; offsets or "kicks" shall be permitted only to enter outlet box.
3. Support exposed conduits on centers not exceeding 2'0" and within 12" of each outlet box using **two hole conduit straps** attached to surface with non-removable break off security type bolts. Alternately, provide hat channel cover as detailed by the Engineer.

L. All conduits shall be supported in accordance with ASCE 7 Chapter 13.

M. Furnish and install a listed expansion/deflection fitting or other approved means where a raceway crosses a structural joint intended for expansion, contraction, or deflection, used in buildings or other structures as required by the Electric Code in 300.4-H. Furnish and install electrical continuity by bonding jumpers or other means as required by 250.98 of the Electric Code."

N. Seal all penetrations through fire and smoke barriers in such a way as to maintain the fire and smoke ratings. Division 26 shall seal all penetrations through interior non-rated walls using fire caulk.

3.2 SEPERATION

A. Cabling and conduit shall be installed in strict compliance with the California Electric Code and TIA 569.

B. Communication, Class 2, and Class 3 wires and cables shall be separated by at least 2 inches from conductors of any electric light, electric power, Class 1, non-power-limited fire alarm, or medium power network-powered broadband communications circuits.
1. Separation can be less if communication, Class 2, and Class 3 circuits are completely enclosed in metallic pathways that are properly grounded and bonded per ANSI/TIA-607-B. Walls of the pathway must have a minimum thickness of .04 inches if made of steel or .06 inches if made of aluminum.
2. Separation can be less if any electric light, electric power, Class 1, non-power-limited fire alarm, or medium power network-powered broadband communications circuits are completely enclosed in metallic pathways that are properly grounded and bonded per

ANSI/TIA-607-B. Walls of the pathway must have a minimum thickness of .04 inches if made of steel or .06 inches if made of aluminum.

3.3 PULL BOX INSTALLATION

A. Pull boxes and junction boxes installed in finished spaces shall be flush mounted cabinets provided with trim, hinged door, and flush latch and lock to match panel trim for flush mounted electrical panel board.

B. Pull boxes and junction boxes installed in unfinished spaces shall be galvanized boxes with covers held by screws.

C. Junction boxes installed exposed to the weather shall be watertight NEMA IV.

D. Pull boxes shall be provided where indicated on the drawings and where required to facilitate the installation of conductors. Pull boxes shall be installed exposed only in unfinished spaces, unless otherwise indicated on the drawings, and shall be installed to be fully accessible as required by the California Electrical Code.

E. Splices are not permitted in pull boxes except when approved in writing by the Architect or where shown on the drawings. Pull all wires in a single continuous run between devices and terminating screws.

F. All boxes shall be supported in accordance with ASCE 7 Chapter 13.

3.4 OUTLET BOX INSTALLATION

A. Ceiling: Flush mounted outlet boxes for devices mounted on the ceiling shall be 4" square boxes 1-1/2" deep. Where installed in concrete, outlet box shall be provided with an extension ring and sealed for installation in concrete.

B. Wall: Flush mounted outlet boxes for devices mounted in walls shall be 4" square boxes, 1-1/2" deep with square edge tile type cover.

C. Alternate: Where only one conduit enters box, 3-1/2" deep single gang switch box may be used.

D. Outlet boxes for devices surface mounted on walls or concrete ceiling shall be FS boxes with matching device plate.

E. Where a special purpose device requires a larger outlet box than specified herein, provide outlet box suitable for specific device. These outlet boxes shall be of the same type as specified herein for the installation required.

F. Where a low voltage device is installed in a common box with a line voltage device, provide metal barrier within outlet box to establish two separate compartments.

G. Review architectural drawings for areas where outlets occur within specific architectural or structural features and install outlets as shown on architectural drawings. If not shown, accurately center and align boxes within the architectural feature or detail.

H. Outlet boxes for flush mounted devices shall be set to within 1/8" of finished wall.

I. All boxes shall be supported in accordance with ASCE 7 Chapter 13.

3.5 FIELD QUALITY CONTROL

A. Licensed Electrician: All conduit and raceway for low voltage systems shall be installed by a Master Licensed Electrician.

B. Debris: All conduits, pull boxes, junction boxes, and outlet boxes shall be installed free of concrete, dirt or other debris.

C. Future conductors: All conductors not energized for this project shall be terminated on both ends and labeled for “Future”.

D. Alignment: All conduits shall be installed parallel to walls and ceilings.

E. Bends: All conduit shall be installed to minimize bends and offsets.

F. Youth areas: Do not install pull boxes, conduits, or junction boxes in space normally accessible to youths.

G. Seismic: All raceway shall be supported in accordance with ASCE 7 Chapter 13.

END OF SECTION 280500.2

SECTION 28 0548 - VIBRATION AND SEISMIC CONTROLS FOR SECURITY SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. 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. Anchoring and restraints.

B. Related Sections
   1. Section 280500.2 - Security & Communication Conduit / Raceway Systems.
   2. Section 284619 – PLC.

1.3 REFERENCES

A. ASTM E2265- Standard Terminology for Anchors and Fasteners in Concrete and Masonry.

1.4 SYSTEM DESCRIPTION

A. Design Requirements
   1. Provide seismic components for the following systems:
      a. 280500.1 UPS system
      b. 282300 IP Video Surveillance
      c. 283111 Digital Addressable Fire Alarm
      d. 284600 Touchscreen Control Station
      e. 284619 PLC
   2. Provide seismic restraints for the listed materials and equipment. The attachments shall resist forces to the center of gravity of the component. Criteria shall be the operating weight of the item times 0.5g for horizontal force to be applied in any direction. Wall-mounted or suspended components shall in addition, resist a downward force of 200 pounds minimum added to the operating weight.
   3. The Importance Factor (I_P) of the above systems equals 1.5.
   4. From the Structural plans, the applicable seismic design parameters are as follows:
      a. Site Class D.
      b. Occupancy Category III.
      c. Seismic Design Category D.
      d. Refer to S0.0 to confirm these parameters.

1.5 SUBMITTALS

A. Submit under provisions of Section 013300.

B. Submit proposed system to engineer for review prior to installation.

C. Project Information:

1. Submit seismic support calculations for all electrical equipment and conduit where isolation restraints are supplied.
2. Certification of seismic restraints.
   a. Substantiated by calculations or test reports verified by a professional structural engineer or equipment manufacturer.

D. Shop Drawings
   1. Submit seismic restraint installation shop drawing prior to installation.

1.6 QUALITY ASSURANCE

A. Racks and Conduits: ASCE 7 Guidelines, Chapter 13 "Seismic Design Requirements for Nonstructural Components".

B. Anchor Bolts: All anchor bolts shall comply with ASTM A307.

C. Certifications: All Seismic components shall be certified as seismic by the manufacturer or by a delegated design professional as specified in specification section 013300 paragraph 2.3.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable Manufacturers:
   1. Seismic Control Devices:
      a. Mason Industries.
      b. Vibration Eliminator Co.
      c. Korfund Dynamics Corp.
      d. Amber-Booth Co.
      e. Consolidated Kinetics.
      f. Kinetics Noise Control

B. Furnish and install racks equivalent to Lowell LER-4432 23” wide by 32” deep by 84” high.

C. Provide conduit and equipment anchoring systems as indicated in the Contract Documents.

D. Provide all mounting hardware, support wires, conduits for alignment, eyebolts, bolts, nuts and washers required for equipment mounting and seismic control. Structural blocking/backing and hardware required for installation shall be provided as required by the Delegated Design Submittal.

2.2 ANCHORING AND RESTRAINTS

A. Equipment Anchors:
   1. Anchor all equipment in accordance with the approved shop drawings.
   2. Contractor shall be responsible for design and acquiring of approval for anchoring of equipment where required by ASCE 7.

B. Conduit Supports:
   1. Conduits shall be supported and braced in accordance with ASCE 7 Chapter 13.

2. Conduits individually supported above finished floors with an importance factor of 1.5 and greater than 2.5 inches in diameter shall be provided with seismic restraints as required by ASCE 7, Chapter 13.
3. Trapeze supported conduits with a total weight exceeding 10 lb/ft shall be provided with seismic restraints as required by ASCE 7, Chapter 13.
4. Cable trays must be listed for seismic installation in accordance with ASCE 7, Chapter 13. Securely attach cable to tray at intervals equal to one half the cable tray support spacing.

C. Device Support:
1. Provide independent seismic support system for all boxes not directly anchored to concrete walls or concrete ceilings for the following:
   a. Cameras.

D. Floor Mounted Racks:
1. Furnish and install seismic racks and attach per manufacture's installation instructions.
2. Furnish and install seismic restraints for shelf mounted computers, monitors, and any other component not securely attached to the frame.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturers' written instructions in a manner to achieve full capacity of support.

END OF SECTION 280548

SECTION 281000 – FIBER OPTIC TESTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Perform and document testing of all optic fiber installed for IP Video, PLC, and security systems. This specification does not apply to infrastructure furnished under Division 27. Refer to specification section 271500 for all Division 27 testing requirements.

B. All testing is to be performed by a certified experienced tester of a nationally recognized certification organization. (Fiber Optic Association)

C. The test result shall be a graphic representation of the relative power versus the fiber length called a “signature trace”.

1.3 SCOPE OF WORK

A. This section includes the minimum requirements for Tier 2 of TSB-140 testing of the optic fiber installed for all security systems networks.

B. Test multimode optic fibers at both 850 nm and 1300 nm wavelengths.

C. Test single-mode optic fibers at both 1310 nm and 1550 nm wavelengths.

D. Test for continuity and quality of all installed optic fibers. Any deficiencies found shall be corrected by the optic fiber installer and the corrected optic fiber retested and documented.

E. The final fiber signature traces for each optic fiber as corrected shall be included in the O&M manuals turned over to the owner.

1.4 QUALITY ASSURANCE

A. All equipment shall be installed neatly and in accordance with manufacturers’ specifications. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner’s Representative. Equipment and materials shall be of the quality and manufacture indicated.

B. Material and work specified herein shall comply with the applicable requirements of:
   1. ANSI/TIA/EIA – 568-B.1: “Commercial Building Telecommunications Cabling Standard”
   2. ANSI/TIA/EIA – 526-7: “Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant”

3. ANSI/TIA/EIA – 526-14A: “Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant”
4. NFPA 70
5. BICSI Telecommunications Distribution Methods Manual
6. Contractor must have at least one Registered Communications Distribution Designer RCDD® on staff.

1.5 SUBMITTALS

A. Submit testing plan for facility optic fiber with submittals.

B. Submit the following certifications:
1. Current certificate of RCDD®.
2. Certification in optic fiber testing.

PART 2 - PRODUCTS

2.1 OPTICAL TIME DOMAIN REFLECTOMETER (OTDR)

A. Utilize a high-resolution OTDR to characterize the power loss and power reflected along optical fibers.

B. The OTDR must operate within the range of 850 ± 30 nm or 1300 ± 20 nm for multimode testing in accordance with ANSI/TIA/EIA-526-14-A.

C. The OTDR must operate within the range of 1300 ± 10 nm or 1550 ± 20 nm for single-mode testing in accordance with ANSI/TIA/EIA-526-7.

PART 3 - EXECUTION

3.1 TESTING

A. For multimode optical fiber, perform optical fiber end-to-end attenuation tests in accordance with EIA TIA/EIS-568-B.3 and EIA TIA/EIA-526-14A using an Optical Time Domain Reflectometer (OTDR) to generate a fiber “trace”.

B. For single-mode optical fiber, perform optical fiber end-to-end attenuation tests in accordance with EIA TIA/EIS-568-B.3 and EIA TIA/EIA-526-7 using an OTDR.

C. All testing shall be performed with launch cables of proper length for accurate readings.

D. All testing shall be performed with “receive fiber” length of proper length for accurate readings.

E. Attenuation losses shall not exceed those specified by the fiber manufacturer.

3.2 PROBLEMS

A. All problem or error conditions shall be corrected and retested to provide clean traces of all fibers.

B. Problems requiring correction and retesting include but are not limited to the following:
   1. Fiber Splice – fibers are not to have any splices. They terminate on equipment or patch panels only.
   2. Negative loss reading.
   3. DB Gainer.
   4. Reflective events other than the cable ends.
   5. Excessive Tailing.
   6. Hook on the falling edge of the trace.

3.3 REPORT

A. Compile all corrected signature traces into a report that shall be submitted to the Architect and Owner.
   1. The Contractor shall compile and submit one organized test notebook, in hard copy format, as well as a single electronic copy in Portable Document Format (PDF) that includes all required test results summary tables, and OTDR traces and power meter results of each fiber by each cable tested.
   2. The test notebook and electronic copy shall at a minimum, include the following:
      a. Identification number and name of each fiber.
      b. A summary sheet that clearly illustrates length and measured loss versus budgeted loss for each fiber or connected fiber string.
      c. Calculations and notations for each fiber and wavelength that include total loss, measured dB/km loss and any anomalies over 0.1dB.

B. Organize the signature traces by system as follows:
   1. Furnish the following separation tabs:
      a. County Tele/Data
      b. MCOE Tele/Data
      c. IP Video
      d. PLC
      e. Intercom/audio
      f. CATV
   2. At the beginning of each tabbed section, verbally described the testing procedures used including length of launch and reference fiber cables. The verbal description shall include the manufacturer and exact model number of the OTDR used for the testing. List all OTDR tester and related software settings and defaults.
   3. The electronic copy of the traces shall be organized with a folder for each tab and all files stored in the appropriate folder.

C. Under each system, identify the point of origination and the point of termination as well as the optic fiber number.

END OF SECTION 281000

SECTION 281300 - ACCESS CONTROL SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The ESC as defined in Section 280500 Common Work Results for Electronic Safety and Security shall be responsible for providing and coordinating this system.

1.2 SUMMARY

A. Scope of Work: Provide all components to incorporate locks, readers, and request to exit devices to provide a complete Card access system as indicated on the plans and described herein.

B. Central Control will have override capability over the card access system. Refer to Specification Section 284600.1 Control Matrix for locations.

C. Card access is to be provided for access to Administration areas.

D. Card access is used for the watch tour system.

E. Furnish and install a Morse Watchman KeyWatcher cabinet for key distribution

F. This facility will have a standalone card access system. It will not connect to a County system.

1.3 SYSTEM DESCRIPTION

A. Access Control: The readers shall provide access by operating the door strike and/or electric lock when a valid card is presented during a valid timer period.

B. The readers shall start a watch tour for an officer in the day rooms. There are additional watchtour buttons that are tied in to the card access system in each dayroom. Card Access system is to log valid card swipes and the pressing of the watchtour buttons.

C. Card Access Controller: Provide one PLC output per designated card access controller room for emergency release function where card access doors are emergency released.

1.4 SUBMITTALS

A. Basic Submittals: Provide submittals as required by 280500 Common Work Results for Electronic Safety and Security and as required by the general contract documents.

B. Hardware: Provide wiring diagrams as coordinated with hardware supplier.

C. Point lists: Provide a point list of each door and all monitored points.

D. Provide documentation from the manufacturer that the ESC is certified to install the Card Access System.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. GE Security

B. HID Corporation

C. NexWatch by Honeywell

D. Andover Controls

E. Softwarehouse

F. Indala

G. Hirsch

H. IDenticard

I. Comnet

J. Keri

2.2 DOOR HARDWARE:

A. Coordinate all connections with door hardware provided by others. Provide power to device from security electronics room UPS.

2.3 TERMINAL CONTROLLER (CA):

A. Furnish and install terminal controllers equivalent to Andover ACX5740 Series Ethernet enabled Controller, in wall cabinets as indicated on the drawings. Monitor cabinet tamper switch

B. Terminal controllers shall provide the following as a minimum:
1. Scalable to 64 doors.
2. Minimum 50,000 card holders
3. UL listed 294

C. Furnish and install a dual door module equal to the Keri SCP-DDM for the number of readers indicated on the plans plus at least two spare. Door modules are to be mounted in wall cabinets and connected to headend controller by RS-485 or similar communication cabling methods.

D. Furnish and install an input and output modules equal to the Keri SCP-DDM for the watchtour stations indicated on the plans. Input/output modules are to be mounted in wall cabinets and connected to headend controller by RS-485 or similar communication cabling methods.

E. The card access system shall operate on an independent dedicated network. The network shall consist of fiber between buildings, CAT6A cable inside buildings, and RS-485 (or similar) cable between controller boards. ESC shall furnish and install all components of this network. (excluding conduit provided by Division 26)

F. Provide hardware for the number of readers and watch tours indicated on the plans plus at least two spare.

G. Enclosures shall be Hoffman or Unity Manufacturing (or equal).

H. Provide an Altronix AL1024ULX Power Supply/Charger (or equal) where indicated on the plans.

I. Provide Altronix ACM8 Access Power controller (or equal) where indicated on the plans.

J. Provide Altronix PD8 Power distribution devices (or equal) where indicated on the plans.

K. The cabinet tamper switch shall be G.E. Security 3010 series recessed pin plunger model 3012-N (or equal).

2.4 CARD READER (RDR):

A. Proximity Card Reader: Furnish and install 125 kHz proximity card readers equal to ProxPro series. As a minimum, the unit shall have the following features:
1. Sealed in a rugged weatherized polycarbonate UL 94 material.
2. Card Readers shall be UL 294 listed.

2.5 REQUEST TO EXIT (REX):

A. Furnish and install a request to exit device where indicated on the plans.
1. Request to exit device with an “M” is a motion detector mounted above the door. Device shall be equal to the Dortronics 6612 Motion Sensor. Install the detection range such that the door is unlocked only when a person approached the door to leave.
2. Request to exit device noted with a “B” is a push button mounted next to the door equal to the Camden CM-400.
3. Request to exit device noted with an “H” is a function of the door hardware.

2.6 DOOR POSITION SWITCH:

A. If a detention DPS is not present, SSI to furnish and install GE door position switches wired to the card access system to indicate that the door is closed.

2.7 CARD ENROLLMENT STATION (CAE):

A. Furnish and install an operator enrollment station computer, monitor and printer. Locate the enrollment station in Building 4, Probation Manager room 167.

B. Camera: Furnish and install a camera equivalent to Kodak FZ41 Camera.
1. Minimum 10 Megapixel camera.
2. Minimum of USB 2.0 compatibility.
3. Desk mounted tripod.

4. 32GB memory card.
5. Rechargeable batteries.

C. The CAE machine shall be equal to the Dell Precision T1700 Workstation which consists of the following:
1. An IBM™ compatible computer with an Intel™ I5-4690 microprocessor chip set or equivalent. The operating speed shall be a minimum of 3.50GHz.
2. Latest version of Windows operating system.
3. 500 GB hard drive
4. Two primary 4GB DDR3 RAM
5. All necessary boards for integration to local area network.
6. Minimum 16X DVD-ROM Read/Write CD/DVD drive
7. Gigabyte Network Interface Card.
8. A nineteen-inch (19") LCD flat screen monitor equal to NEC AccuSync ASLCD92V.

D. Furnish and install all software required for a fully functional system.

2.8 CARD ACCESS ALARM TERMINAL (CAA):

A. Furnish and install a Card Access Alarm Terminal consisting of a computer, monitor, mouse, and keyboard. Locate the enrollment station in Building 4, Central Control room 102.

B. The CAA machine shall be equal to the Dell Precision T1700 Workstation which consists of the following:
1. An IBM™ compatible computer with an Intel™ I5-4690 microprocessor chip set or equivalent. The operating speed shall be a minimum of 3.50GHz.
2. Latest version of Windows operating system.
3. 500 GB hard drive
4. Two primary 4GB DDR3 RAM
5. All necessary boards for integration to local area network.
6. Minimum 16X DVD-ROM Read/Write CD/DVD drive
7. Gigabyte Network Interface Card.
8. A nineteen-inch (19") LCD flat screen monitor equal to NEC AccuSync ASLCD92V.

C. Furnish and install all software required for a fully functional system.

2.9 PROXIMITY CARDS:

A. Furnish and install 500 proximity cards compatible with the readers furnished and installed under Division 28: The cards will be used for facility identification badges.

B. Furnish to the owner 500 card clips and 500 lanyards.

2.10 CARD PRINTER:

A. Printer: Furnish and install a printer equivalent to Fargo DTC1250C Double Sided ID Card Printer.

B. All art work shall be as approved by the owner.

2.11 EVENT RECORDING:

A. The Card access system shall record all events in an SQL database and allow custom owner reporting.

2.12 WATCH TOUR:

A. Furnish and install the quantity of watch tour stations indicated on the plans. Each watch tour station is a combination of an indicator and a switch mounted to a plate.

B. Watch Tour Switch: The watch tour switch shall be a ceramic-based piezoelectric switch equal to Everswitch SMB series mounted on an 11-gauge stainless steel plate. The switch shall be black with an integral red LED.

C. Watch Tour Plate: The device plate shall be an 11-gauge stainless steel plate fabricated to mount to a two-gang box. The plate shall be approximately 4.5 inches square. Secure the plate to the box with four security screws.

D. For Site Watch Tour devices, provide Comnet Fiber Cards FDC10RM1A contact closure transceiver for the pole mount and FDC10RM1B for the contact closure in the Security Rack.

2.13 KEY CABINET:

A. Furnish and install a Morse Watchman KeyWatcher cabinet for key distribution. Keys shall be dispensed based on the access settings of each staff member as determined by the owner.

B. Provide a key cabinet that holds a minimum of 50 sets of keys in the location identified on Sheet SE1.4.1.

2.14 CABLING AND WIRE:

A. Acceptable manufacturers:
1. Liberty Wire and Cable
2. Eastman Wire & Cable
3. West Penn Wire
4. Belden
5. Carol
6. General Cable
7. Clifford of Vermnont, Inc.
8. Alpha

B. Wire Size: Furnish and install sufficient wire gauge to limit voltage drop to 5%.

C. Listings: Wiring shall be listed for the installation.

D. Access Terminal Controller Wiring: Furnish and install a two conductor #20 AWG stranded with overall shielded cable or Ethernet Category 6A.

E. Card Reader Wiring: Furnish and install a five conductor #20 AWG stranded with overall shielded cable to each card reader.

F. Request to Exit Wiring: Furnish and install a two conductor #20 AWG cable to each request to exit wall switch.

G. Door Position Switch Wiring: Furnish and install a two conductor #20 AWG cable to each door position switch.

H. Watch Tour Wiring: Furnish and install a four conductor #20 AWG cable to each watch tour.

I. Conductors shall be grouped and laced with nylon tie straps.

J. All power conductors shall be a minimum 14 AWG THWN, 600 volt rated and shall be installed in raceways and equipment enclosures with other conductors within limitations defined by Article 300 of the California Electric Code.

K. Class 2 Circuit Wiring that extends from the electronic control relay terminal trips to the low voltage devices shall be Class 2 as defined by article 725 of the California Electric Code. All control conductors shall be a minimum of 20 AWG, jacketed, control cable. All control cable insulation shall be 600 volt rated.

L. All wiring systems shall be labeled and color-coded with labeling and coding shown on shop drawings.

M. All conductors within junction boxes pull boxes, and equipment enclosures shall be grouped and laced with nylon tie traps.

N. Control system conductors shall not be spliced.

PART 3 - EXECUTION

3.1 COORDINATION

A. Preliminary Coordination: Coordinate all required embeds, block-outs, and construction as required to install the devices as indicated on the plans.

B. Hardware: Coordinate connections to hardware provided by others.

3.2 INSTALLATION

A. Coordination: Fully coordinate the card access equipment with all other trades for a complete and operational system.

B. Listing: All wiring and raceways shall be listed for the intended installation and installed in strict accordance with the National Electric Code as required by the conditions of where it is installed.

C. Seismic: The entire system shall be installed to meet the seismic requirements for the area.

3.3 FIELD QUALITY CONTROL

A. Tests: Test that all readers respond correctly to all alarm events as well as unlocking the door on a valid card read.

B. Test Reports: Provide written test reports documenting all of the above with either a narrative for each point or a list of features noting “pass” or “fail”.

3.4 TRAINING

A. The ESC shall provide, without additional cost to the owner, representatives specially trained in the operation of Access Control system provided. The representatives shall train the Owner’s personnel in operation, repair, and upkeep of this system.

B. The ESC shall be responsible for notifying the architect five (5) weeks prior to substantial completion of the total security system that training is scheduled. The ESC will coordinate the number to be trained with the owner’s representative.

C. The length of training shall be at least four hours long and be presented to all shifts.

D. Course Structure
   1. The ESC shall prepare and present to the Architect a detailed course outline that specifies each major training module to be covered. The training program on the security equipment shall include the sequences and instructions for proper use and maintenance of all hardware, locking devices, control and monitoring systems and panels. The material content shall be in simple layman’s terminology, describe and demonstrate all step-by-step physical operations necessary for proper operation and necessary equipment adjustments. At the time of training, each trainer shall present to the trainees detailed outlines of each training module to be covered and the specific skills and knowledge which the trainee is expected to master within each training module.
   2. At a minimum the training program shall be subdivided into the following training modules:
      a. Operation of the Access Control System.
      b. Troubleshooting, General Maintenance, Equipment Adjustments, Repair and Replacement of Access Control Components.
      c. Operator Controls.
      d. Descriptive modules organized by specification section.
      e. Review of panel as built plans and submittals.
      f. Review of Operation and Maintenance Manuals.
      g. Review of all contact telephone numbers.
      h. Review of all warranties.

E. The ESC shall record each training module. The recording does not have to include individual student practice. The ESC in preparing the recording shall structure it for easy reference by the facility’s training officer for future use. Furnish to the owner DVD's or digital media copies on the ERC machine as required by the owner.

F. Training Certification
   1. Each facility employee shall receive at the conclusion of the security systems training program a certificate certifying his attendance of the total session or portion thereof.
   2. ESC shall maintain attendance records of each class.

G. In addition to the training requirements listed above the ESC shall include all associated cost to provide additional onsite owner training following substantial completion. The additional training shall occur at the three (3) months periods and shall cover topics as referenced in paragraph “D” above. Coordinate this additional training with the owner.

3.5 SPARES

A. Furnish the following Spares:
1. One spare reader.
2. One spare of each type door board installed on the project.
3. One spare of each power supply installed on the project.
4. One spare complete (plate included) watchtour device.

B. Spare parts shall be packaged with appropriate protective packing material.

C. Box spare parts for easy storage and clearly identify the contents of each box on four sides of each box.

ACCESS CONTROL VERIFICATION AND CHECK-OUT FORM

✓ = OK

Job #
Job Name:
Panel #

FIELD TEST CODE:		**REPAIR CODE:**	
A - No status change	M - Reversed	1-SSI	Software Test By:_____ Date_____
B - No power card reader	N - No event recording	2-ELECTRICIAN	
C - No power to door	O - No power to printer	3-IRONWORKER	Hardware Test By:_____ Date_____
D - Door won't open	P -	4-CARPENTER	
E - Door won't close	Q -	5-OWNER/REP	System Test By:_____ Date_____
F - Wrong door opens	R -	6-ENG	
G - Adjust door	S -	7 -	Design Engineering By:_____ Date_____
H - Doors emergency release SCC	T -	8 -	
I - Adjust DPS	U -	9 -	Wiring By:_____ Date_____
J - Motion detection failure	V -	10 -	
K - Software problem	W -	11 -	Field Test By:_____ Date_____
L - Not installed	X -	12 -	

							ON-SITE				
ICON ID#	**ICON TYPE**	**STA CALL NO.**	**CA INTLK WITH**		**SOFT-WARE TEST**	**CA TEST**	**FIELD TEST CODE**	**REPAIR CODE**	**RE-CHECK "X"**	**FIELD CHECK OUT NOTES**	**PROBLEM RESOLVED (BY/DATE)**

END OF SECTION 281300

SECTION 282300 – IP VIDEO SURVEILLANCE

PART 1 - GENERAL

1.1 SUMMARY

A. Scope of Work: Furnish and install all components to provide a complete, integrated, and fully functional Internet Protocol (IP) camera system as indicated on the plans and described herein.

B. The ESC as defined in Section 280500 Common Work Results for Electronic Safety and Security shall be responsible for providing and coordinating this system.

C. The ESC shall provide all local video switches, video servers, video management software, camera licenses, and programming of cameras and network equipment required for a fully functional system.

D. Provide recording of all cameras for a period of 12 months. Video storage array shall be a minimum of 760 Terabytes in size. Refer to camera schedule for recording parameters of each camera.

E. The video system shall be interfaced with the PLC/TCS system for intercom, systems alarms, and individual camera call up functions.

F. System analytics shall alarm in central control any time a person is detected approaching the fence from inside or outside the facility. Alarms shall activate when a person is approximately ten feet from the fence. ESC is to provide necessary hardware, software, camera license, and any auxiliary equipment required to provide this function.

1.2 SYSTEM DESCRIPTION

A. System Capacity: Furnish and install a color IP camera system with the capacity indicated plus 25% spare.

B. Video Management System (VMS): a Video Management System on a central server will be provided by the ESC to control all IP cameras.

C. Multiplex Monitor Station: Furnish and install color monitors and CPU’s to view up to 16 camera views simultaneously or as selected by the operator.

D. Spot Monitor Station: Furnish and install color monitors and CPU’s to display a camera activated by alarm, intercom call up, or manual activation.

E. Camera Identification: Uniquely identify each camera by a 16 character, alphanumeric label incorporated into the video signal.

F. IP Camera: Furnish and install all cameras and camera cabling. The IP camera shall provide at least two individually configured simultaneous video streams.

G. Continuous Operation: All cameras, computers, and system components shall be rated for continuous operation.

H. Standards: All cameras and components shall be compliant with a single standard, either ONVIF or PSIA.

I. Fully integrate the IP video system with the Door Locking Control PLC and Intercom systems.

J. Video Storage: ESC shall furnish and install a video storage array sized to provide 365 days of video storage for all of the IP video cameras.

K. Perimeter cameras shall go into an alarm state when a person approaches the perimeter fence within the cameras' field of view. The alarmed camera shall be instantly displayed on the multiplexed monitor in Central Control. Two camera views on each multiplexed monitor shall be used for displaying site cameras that are in alarm. The operator shall acknowledge the alarm by clicking on the camera view. ESC shall provide the programing and testing of this feature of the camera system.

1.3 SUBMITTALS

A. Basic Submittals: Provide submittals as required by Section 280500 Common Work Results for Electronic Safety and Security and as required by the general contract documents.

1.4 SYSTEMS INTEGRATION

A. Alarm Call-up: Cameras covering a duress button shall automatically display live video on the controlling spot monitor whenever the duress button is activated.

B. Intercom Call-up: Cameras covering an intercom station shall automatically display live video on the controlling spot monitor whenever the intercom is selected by the controlling Touchscreen Control Station (TCS).

PART 2 - PRODUCTS

2.1 ACCEPTABLE IP VIDEO MANUFACTURERS

A. Acceptable hardware manufactures IP Video equipment:
   1. Bosch
   2. Vicon

B. Bosch is used as a basis of design. Comparable equipment from other manufacturers may be used as long as all specified requirements are incorporated.

2.2 SYSTEM PARAMETERS

A. Manufacturing Standards: All components shall be manufactured to a single standard, either ONVIF or PSIA.

B. All components shall incorporate the following:

1. UL listed for the intended purpose.
2. Vandal resistant housing.

C. Network Features: All components operate over Ethernet switches, Cat 6A cabling and optic fiber. All components shall incorporate the following:

1. Compatible with Internet Protocol Version 4 (IPv4) and Version 6 (IPv6).
2. Support both fixed and dynamically assigned IP addresses.
3. Shall have the ability to limit maximum bandwidth to a selected value.

2.3 IP VIDEO CAMERAS

A. Furnish and install where indicated in the camera schedule interior IP cameras equal to Bosch Flexidome HD model NIN-733-V03P series with cast aluminum housings and polycarbonate dome and 1280x720 resolution.
1. Vandal resistant construction IK10 impact resistant.

B. Furnish and install where indicated in the camera schedule interior IP cameras equal to Bosch HD model NIN-832-V03P series with cast aluminum housings and polycarbonate dome and 1920x1080 resolution.

1. Vandal resistant construction IK10 impact resistant.
2. Powered over Ethernet.
3. Pendant mount cameras below duct work and lighting in dayrooms to provide an unobstructed view. Mount cameras a minimum of 8’ (horizontally) from mezzanine level.

C. Corner mounted cameras in cells shall be equal to Bosch NCN-90022-F1 corner mount unit.

1. Vandal resistant construction.
2. Powered over Ethernet.
3. No grip, anchor free design.

D. Furnish and install where indicated in the camera schedule exterior 5 MP cameras for the perimeter equal to Bosch NBN-80052-BA Dinion IP Starlight 8000 MP with 2992x1680 resolution
1. Vandal resistant construction IK10 impact resistant.
2. Powered over Ethernet
3. Bosch UHO-PoE-10 with LTC 9213/01 pole mount.
4. 30 images per second frame rate.
5. Video Analytics that alert staff when a person is within 10’ of the perimeter fence. ESC is to provide necessary hardware, software, camera license, and any auxiliary equipment required to provide this function.

E. Furnish and install where indicated in the camera schedule exterior PTZ camera equivalent to VG5-7130EPC4 with 1280x720 resolution.
1. Vandal resistant construction IK10 impact resistant.
2. Powered over Ethernet
3. Bosch arm mount.

F. Exterior units shall be rated IP66 against weather for outdoor mounting.

G. Camera Pole: Furnish and install camera poles with mounting heights as indicated on the plans. Poles shall be Lithonia model RSS 18 4-5B (or equal), round steel and be a minimum of 4" diameter at the top. Color to be dark bronze or as approved by owner/engineer. Pole shall provide a hand hole to access cabling running up the inside of the pole. Pole shall have a weatherproof cap on top of the pole.

2.4 IP VIDEO MONITOR WORKSTATIONS

A. Workstation Computer: At a minimum, furnish and install a Bosch MHW-WZ4R2-HEUS (or equal) computer with all required hardware and software as indicated on the plans.

B. Workstation and Spot Monitors: Furnish and install a 22 inch monitor equal to the Bosch UML-223-90 where indicated on the plans.

C. Multiplexed Monitors: Furnish and install a 32 inch monitor equal to the Bosch UML-323-90 where indicated on the plans.

D. Furnish and install a computers and monitors for each video workstation and each video review location.
   1. IP.4A Central Control 102.
   2. IP.4B Central Control 102.
   3. IP.4C Processing 110.

2.5 IP VIDEO CONTROLS

A. Furnish and install an IP Video Storage Array equal to Bosch/NetApp E2600 dual controller series with a minimum of 3 60 bay expansions. Video storage array shall be a minimum of 760TB in size. Record camera video according to the parameters listed in the camera schedule. Video shall be stored for 12 months. In addition, provide the following features:

   1. Provide RAID 6 storage configuration
   2. System shall be scalable. Provide expansion units equal to Bosch high density 60 bay expansion units with 4 TB hard drives.
   3. Provide active storage for all of the cameras installed in the project.
   4. Provide space for future expansion.
   5. The system shall provide "watermarks" to ensure the video has not been modified.
   6. Video recording manager equal to Bosch BVRM

B. Furnish and install a Software IP Video Management System equal to Bosch BVMS 6, with all components required for a fully functional system.

C. Furnish and install local Ethernet switches for the video system in each control room camera rack and the main server rack as required for the final number of cameras to be installed. The Ethernet switch shall be equal to HP 2620-24-PoE+ 24 port Gigabit Switch with 382 Watts of Power over Ethernet. Each unit shall have the redundant power supply. PoE shall be available on all ports.

D. Furnish and install an aggregating switch equal to HP E5400zl in main SEC room 721. Furnish and install optic fiber SFP ports for connections to remote edge switches. Furnish and install all power supplies, hardware, and software required for a fully functional system.

E. Furnish and install a video server equal to Bosch model MHW-S380R8-SCUS.

F. Furnish and install a Lantronix UDS1100 Media Converter (or equal) for the ASCII interface between the PLC and IP video network.

2.6 TRANSIENT SURGE SUPPRESSION

A. Acceptable manufacturers are as follows:
   1. Northern Technologies Incorporated
   2. DITEK
   3. PolyPhaser Corporation
   4. Transtector

B. Furnish and install surge suppression on all power connections to exterior cameras equal to Northern Technologies TCS-HWR.

2.7 FIBER OPTIC MODULES

A. Furnish and install dedicated multimode optic fiber between Video Ethernet switches and remote exterior cameras. Fiber shall be equal to Corning FREEDM 002T8F-31180-29. Furnish and install quantity of optic fibers required plus 25% spare.

B. Furnish and install a Comnet Ethernet 2 port media converter CNGE2MC or equal for each pole mounted camera. The unit shall be located in the security electronics equipment rack (VID). If two channels is necessary use CNGE22MC.

C. Furnish and install a Comnet Ethernet 2 port media with PoE converter CNGE2MCPOEM or equal for each pole mounted camera. The unit shall be located in the camera pole power cabinet.

2.8 CABLING AND WIRE

A. Acceptable manufacturers:
   1. Commscope Uniprise Cat 6A cable.
   2. Commscope Uniprise Cat 6A cable jumpers.
   3. “Wet Rated” shall be equal to CommScope Uniprise 6NF4-i cable.
   4. “Non Wet Rated” shall be CommScope Uniprise 65N4+ cable.

B. Wire Size: Furnish and install sufficient wire gauge to limit voltage drop to 5%.

C. Camera Power Wiring: Interior cameras will be Powered over Ethernet (PoE). Furnish and install 120 VAC UPS power for cameras connected by optic fiber. Coordinate the location and installation of 120 VAC UPS power with Division 26.

D. IP Camera Wiring: Furnish and install category 6A cabling from each IP video device to the nearest switch.

E. Category 6A cable for all cameras shall be GREEN in color.

F. All factory patch cords shall be GREEN in color.

2.9 EQUIPMENT ENCLOSURES

A. The IP Video system equipment shall be mounted in seismic rated rack. Furnish and install racks equal to CPI Seismic Frame series Cabinet.

B. Each workstation computer shall be provided with low profile metal cabinet to house the computer. Furnish each CPU with a model CPU-1 or CPU-2 cabinet as manufactured by Computer Security Products. Furnish and install the following as a minimum:
   1. Fully vented steel doors.
   2. Welded side panels with handles.
   3. Equipment rack noted here is not required if millwork is fabricated with ventilated and lockable storage area for CPU's.

2.10 FABRICATION

A. Assemble all components in a neat and orderly fashion.

B. Identify camera with text approved by the owner.

2.11 CAMERA POLE

A. Furnish and install a camera pole and base at each pole mounted camera shown on the site plan. The camera signal shall be over optic fiber to the pole enclosure. Furnish and install a ground rod at each camera pole.

B. Camera pole to be equal to Lithonia model RSS Round Straight Steel pole with anchor base and round cap. Pole to be 18' tall and 4" in diameter. All fasteners to be stainless steel unless otherwise noted.

C. Top part of anchor bolts shall be galvanized per ASTM A-153 and made of steel rod having a minimum yield strength of 55,000 psi. Submit finish to the architect for approval.

D. Furnish and install a hand hole and Full Base Cover.

E. Furnish and install all hardware required to mount the equipment enclosure and camera as indicated in the plans and details.

F. Assemble all components in a neat and orderly fashion.

2.12 CAMERA POLE POWER CABINET

A. Furnish and install camera pole power cabinet equal to Hoffman A20H16ALP, NEMA 4 rated enclosure (20"H x 16"H x 6"D). Mount PoE Fiber Media Converter, Fiber Media Converter (Watchtour), TVSS (TCS-HWR), fuse terminal with (2) Amp fuse, terminals, receptacle, and ground buss bar. Division 26 shall furnish and install a (2) Amp 120 VAC UPS Power circuit to each camera power cabinet. Owner to furnish padlock to lock the enclosure. Refer to sheet SE1.0.0, details 4 and 6 on sheet SE5.0.2.

PART 3 - EXECUTION

3.1 COORDINATION

A. Preliminary Coordination: Coordinate all required embeds and block-outs as required to install the cameras as indicated on the plans.

B. Construction Examination: Monitor ongoing construction and coordinate with other trades so that a clear line of site of the area to be viewed is maintained for each camera.

C. Structural Examination: Examine locations for camera mounts and poles to ensure the supporting structures will carry camera mounts and devices to be installed.

3.2 INSTALLATION

A. Conduit: All conduits are to be concealed.

B. Cable: All connecting cables to cameras shall be concealed in the mount or installed with flexible conduit. Flexible conduit not allowed in youth housing areas.

C. Anchoring: All mounts shall be anchored to the walls or structures as indicated in the installation manuals.

D. Special Boxes: Furnish and install special back boxes in a timely manner for field installation while adequate access is available.

E. Titles: Program camera identifications and intercom call up titles as approved by the Owner.

F. Field Wiring: The wiring that extends from the electronic control relay terminal strips to the locks, lights, etc. shall be class 1, 2, or 3 as defined by Article 725 of the California Electric Code.

3.3 FIELD QUALITY CONTROL

A. Testing: All cameras shall be tested and viewed from each scheduled monitor after installation is complete.

B. Integration Testing: Check that all integrated events call up the appropriate camera.

C. Test Reports: Furnish written test reports to the engineer prior to final inspection documenting all of the above. See example form below.

VIDEO SURVEILLANCE VERIFICATION AND CHECK-OUT FORM

✓ = OK

Job #
Job Name:
Panel #

FIELD TEST CODE:		REPAIR CODE:	
A - No status change	M -	1-SSI	Software Test By:_____ Date_____
B - Won't call up with alarm	N -	2-ELECTRICIAN	
C - Poor vIdeo	O -	3-IRONWORKER	Hardware Test By:_____ Date_____
D - No video	P -	4-CARPENTER	
E - Out of focus	Q -	5-OWNER/REP	System Test By:_____ Date_____
F - PTZ does not function	R -	6-ENG	
G - No power to camera	S -	7 -	Design Engineering By:_____ Date_____
H - Reversed CCTV Camera call-	T -	8 -	
I - Software problem	U -	9 -	Wiring By:_____ Date_____
J - Monitor failure	V -	10 -	
K - Multiplex/Quad failure	W -	11 -	Field Test By:_____ Date_____
L - Not installed	X -	12 -	

							ON-SITE				
ICON ID#	ICON TYPE	C/U CAM. NO.	CCTV INTLK. WITH	CELL CCTV VIDEO	SOFT-WARE TEST	HARD-WARE TEST	FIELD TEST CODE	REPAIR CODE	RE-CHECK "X"	FIELD CHECK OUT NOTES	PROBLEM RESOLVED (BY/DATE)

D. Program camera identifications and intercom call up titles as approved by the owner.

E. Field test each perimeter test camera by approaching the fence from each direction.

3.4 SOFTWARE

A. Furnish a single Adobe Acrobat PDF file detailing all passwords for each IP Video system.

B. Furnish documents listed in 3.4 A at project completion.

3.5 ADJUSTING AND CLEANING

A. View Adjustment: Use a portable monitor to adjust the cameras for the best possible camera coverage. Final adjustments shall be reviewed and approved by the owner.

B. Fully coordinate the final location of all cameras to prevent camera views being blocked by light fixtures, HVAC fixtures, and all other obstructions.

3.6 TRAINING

A. The ESC shall provide without additional cost to the owner representatives specially trained in the operation of Video Surveillance systems provided. The representatives shall train the Owner's personnel in operation, repair, and upkeep of the Video Surveillance and custom recording settings.

B. The ESC shall be responsible for notifying the architect five (5) weeks prior to substantial completion of the total security system that training is scheduled. The ESC will coordinate the number to be trained with the owner's representative.

C. The length of training shall be at least four hours long and be presented to all shifts.

D. Course Structure
   1. The ESC shall prepare and present to the Architect a detailed course outline that specifies each major training module to be covered. The training program on the security equipment shall include the sequences and instructions for proper use and maintenance of all hardware, locking devices, control and monitoring systems and panels. The material content shall be in simple layman's terminology, describe and demonstrate all step-by-step physical operations necessary for proper operation and necessary equipment adjustments. At the time of training, each trainer shall present to the trainees detailed outlines of each training module to be covered and the specific skills and knowledge which the trainee is expected to master within each training module.
   2. At a minimum the training program shall be subdivided into the following training modules:
      a. Operation of the Video Surveillance System.
      b. Troubleshooting, General Maintenance, Equipment Adjustments, Repair and Replacement of Video Surveillance System Components.
      c. Operator Controls.
      d. Descriptive modules organized by specification section.
      e. Review of equipment rack as built plans and submittals.
      f. Review of Operation and Maintenance Manuals.
      g. Review of all contact telephone numbers.
      h. Review of all warranties.

E. The ESC shall record each training module. The recording does not have to include individual student practice. The ESC in preparing the recording shall structure it for easy reference by the facility's training officer for future use. Furnish to the owner DVD's or tape as required by the owner.

F. Training Certification
   1. Each facility employee shall receive at the conclusion of the security systems training program a certificate certifying his attendance of the total session or portion thereof.
   2. ESC shall maintain attendance records of each class.

G. In addition to the training requirements listed above the ESC shall include all associated cost to provide additional onsite owner training following substantial completion. The additional training shall occur at the three (3) months periods and shall cover topics as referenced in paragraph "D" above. Coordinate this additional training with the owner.

3.7 SPARES

A. Dome Camera: Furnish (2) spare cameras of each type installed on the project.

B. PTZ Camera: Furnish (1) spare camera of each type installed on the project.

C. Corner Mounted Camera: Furnish (1) spare camera of each type installed on the project.

D. Workstation: Furnish one spare workstation with monitor.

E. Spare parts shall be packaged with appropriate protective packing material.

F. Box spare parts for easy storage and clearly identify the contents of each box on all four sides of each box.

END OF SECTION 282300

SECTION 28 3111 - DIGITAL ADDRESSABLE FIRE ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

General provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this section.

A. The ESC as defined in Section 280500 Common Work Results for Electronic Safety and Security shall be responsible for providing and coordinating this system.

B. Refer to Mechanical specifications and drawings for responsibilities, sequence of operation and for coordination requirements.

C. All Fire Alarm wiring shall be in conduit. Conduit is provided by Division 26. Refer to 280500.2 for conduit and cable requirements. ESC is responsible for coordinating conduit with Division 26.

D. Refer to Specification Section 230993 for Sequence of Operations for HVAC controls.

1.2 SCOPE OF WORK

A. Furnish and install a complete, and ready for operation, automatic fire detection and alarm system. System shall include control panel, detectors, annunciators, manual stations, alarm devices, wiring, components, relays, accessories, and all wiring and connections to devices furnished by others. Coordination with divisions 23 and 26 is required to assure that system operates correctly.

B. Provide monitoring of the kitchen hood extinguishing system. Monitor all fire sprinkler and extinguishing systems furnished and installed by others.

C. Miscellaneous points shall be monitored or controlled by an addressable module located within three feet of the device controlled as required by NFPA 72 6.15.2.2. Program the device into the nearest Fire Alarm Control Panel. Wiring that leaves the building shall be provided with a transient voltage surge suppressor at the exit point. Furnish and install a ground wire to the facility ground.

D. All Fire Alarm Communications between control panels shall be over the facility fiber optic network. The ESC is to provide fiber and fiber terminations to the Fire Alarm control panels in conduit provided by Division 26.

E. Furnish and install addressable output modules to open and close all smoke/fire dampers.

F. Each address shall have a unique label indicating the building, dayroom, and device type. All labels shall be coordinated with the facility signage and approved by the owner and the Authority Having Jurisdiction.

G. The system shall provide all required points for monitoring, from an on and off site, Central Station including Alarm, System Trouble, Water Flow, and System Supervisory. Provide and install all required components to accomplish this monitoring.

H. Coordinate with Division 23 the shutdown of the HVAC units when their respective duct smoke detectors have been activated. Provide the necessary number of relays to perform this function.

1.3 CODE REFERENCES

A. Applicable Publications: The Fire Alarm system shall be furnished and installed in accordance with the following:
   1. California Building Code
   2. National Fire Protection Association Standard 70.
   3. National Fire Protection Association Standard 72.
      a. Proprietary Supervising Station System.
   4. Local Codes and Authorities Having Jurisdiction.
   5. California Fire Code.
   6. Approved Fire Protection Plan.

B. All equipment shall be UL listed for the intended purpose.

C. All equipment shall be CSFM listed for the intended purpose by the California State Fire Marshall's Office. CSFM listing: the system shall be listed as a system. Plans and calculations to be approved by the Fire Marshal or the Authority Having Jurisdiction (AHJ).

1.4 SYSTEM DESCRIPTION

A. The automatic fire detection and alarm system shall consist of a microprocessor based main control panel, printer, remote annunciator, detection devices, manual stations and alarm indicating appliance and as specified herein.

B. System operation shall be provided with three (3) levels of password protection.

C. The system shall be capable of performing time base control functions and shall contain the ability to be programmed for a holiday schedule.

D. The system shall be capable of operating both intelligent/analog and non-addressable devices.

E. The system shall have a point capacity of 2500 points.

F. The system shall function as follows when an area detector, duct detector, manual station or water-flow switch operates:
   1. Activate audible and visual notification devices in the area of alarm.
   2. Annunciate audibly and visually on Fire Alarm Control Panels (FACP) and Fire Alarm Annunciators (FAA) in the area of alarm as well as Central Control Building 4 Room 102.
   3. Display individual detector and/or zone number on alphanumeric display with user defined message on Fire Alarm Control Panels and Fire Annunciators in the area of alarm as well as Central Control. Building 4 Room 102.
   4. Printed record on FACP printer in central control.
   5. Transmit an alarm signal to the Central Station monitoring the facility.

6. Annunciate kitchen hood system activation in Central Control (Building 4 Room 102).
7. Graphics of actual annunciator and FACP to be to approval of AHJ.

G. Duct detectors shall shut down their respective unit when they sense smoke in the unit.

H. Where smoke dampers are provided on units less that 2000 CFM, furnish and install an addressable module to shut the unit down. Coordinate fully with all trades.

I. System shall monitor and annunciate positive confirmation of fan activation and presence of power as defined by the IBC and these documents.

1.5 AUXILIARY FUNCTION:

A. Provide addressable relay output modules to control smoke exhaust fans.

B. Provide input modules to monitor pressure switches associated with the smoke exhaust fans. If the switch is not indicating air flow within 10 seconds after an alarm is initiated the system should register a trouble on the local fire alarm panel.

C. Furnish and install individual switches on FAA to shut down sprinkler water in Building 2. Activation of this switch shall be monitored as a supervisory condition. Fully coordinate with approved fire sprinkler submittals.

D. Furnish and install a graphic map at each FACP and annunciator panel. Map to show "you are here" and show layout of building and name of areas.

1.6 SUBMITTALS

A. Basic Submittals: Provide submittals as required by Section 280500 Common Work Results for Electronic Safety and Security and division 1.

B. Special Submittal Requirements: In addition to the contract requirements for submittals provide the following:
1. Riser diagram indicating integration with other systems. Identify all major components, interconnections, and subsystems.
2. Identify spare capacity of each circuit either by schedule, device identification, or notation.
3. Battery calculations for each panel.
4. Voltage drop calculations for each signal circuit using the following model:
   a. All device loads will be treated as if at the end of the circuit.
   b. No circuit shall have a voltage drop of more than 10%.
   c. Identify circuit current, voltage drop, wire size, and percentage drop.

C. Approvals and comments from Authorities Having Jurisdiction.

D. Furnish a copy of the license for the master electrician who will supervise the installation of the fire alarm system.

E. Furnish a copy of the UUKL listing for the smoke control equipment.

1.7 SYSTEM INTEGRATION

A. Printer: Provide a dedicated 24 VDC printer built into the network fire alarm panel for recording system alarms in Central Control.

B. HVAC: Integrate the fire alarm with the HVAC system by means of dry contacts and addressable devices.

C. Sprinkler System: Monitor Fire Sprinkler Flow and Supervisory devices provided and installed by others.
   1. Provide individual switch on FAA in the Building 2 housing to shut off water feeding the dayroom if head is accidentally activated. Coordinate location with division 23.

PART 2 - PRODUCTS

2.1 FIRE ALARM SYSTEM

A. ACCEPTABLE MANUFACTURERS
   1. Siemens
   2. EST
   3. Notifier

2.2 FIRE ALARM CONTROL PANEL

A. The main control panel shall be equal to the FireFinder XLS as manufactured by Siemens. The completed system shall have space provided for a minimum of 25% spare slots. The system shall provide the following:
   1. The control panel shall be capable of supporting non-addressable as well as addressable detection devices.
   2. The Person Machine Interface shall be equal to the Siemens PMI graphic user interface.
   3. System shall be capable of a minimum 2500 points.

B. Supervision: Dynamic supervision of system electronics, wiring, detection devices, and software shall be provided by the control system. System failures shall be indicated on the alphanumeric annunciator. Software and processor operation shall be monitored by an independent hardware watchdog circuit, which will indicate their failure.

C. Ground fault: Ground fault detection shall be provided for all circuits.

D. Power: The control panel shall operate from a two wire 120 VAC supply with internal 24 VDC backup battery. All panel power connections whether AC or DC shall be separately fused within the control. The Fire Alarm Control Panel shall furnish low voltage power to all remote fire control relays. Power supplies shall be sized with 25% spare capacity.

E. Analog Operation: The control panel shall measure and adjust within UL guidelines the sensitivity of analog smoke detectors. An alphanumeric display shall be provided for custom operator messages and for reading detector sensitivity. Each device on an intelligent/analog detecting circuit shall be checked continuously.

F. Supervision: The control shall report the failure of a device's transmitting component(s), open or shorted, on an intelligent/analog detection circuit. The device shall be recognized and identified by location within the circuit to the specific device, and all other devices on the circuit shall continue to function properly.

G. Device number: The controls shall report, by specific device number, any device removed from an intelligent/analog detection circuit and all other devices shall continue to function.

H. Printed record: The system shall provide a hard copy written record of all alarms, troubles, and supervisory events. Printer shall meet the requirements for an NFPA 72 Proprietary Supervising Station System.

I. New Alarms: New unacknowledged alarms and troubles shall be distinctively displayed visually differentiated from previous alarms and troubles.

J. System Reset: It shall not be possible to reset the system until all off normal indications have been acknowledged.

K. Logic: Control functions shall be assigned on the basis of system initiation patterns of detection devices such as "anding" zones, counting zones, counting devices, "anding" groups, and "anding" types of detection devices.

L. Addressing: Sprinkler water flow switches, air duct smoke detectors, tamper switches, OS & Y valves, manual stations, and thermal detectors shall be equipped with a unique address.

M. Signal Circuits: Provide notification appliance circuits capable of providing 1.5 amp at 24 VDC per circuit as required to power evacuation signals. All notification appliance circuits shall be Style Z (Class A operation). Circuit visual alarms separately from audible signals. Provide switches to allow the audible signals to be silenced while the visuals continue to flash.

N. The addressable Signaling Line Circuit shall be so constructed that all devices shall continue to communicate even with a single wire fault. (Style 6 - Class A operation)

O. The facility fire alarm system shall meet the requirements for a Proprietary Fire Alarm System as defined by NFPA. Furnish and install all redundant and backup components as required.

P. Provide automatic detectors with built in relays where indicated on the plans or required. Remote relays located on detector bases or double gang outlets throughout the building shall be controlled in the same manner as panel mounted relays.

Q. Provide signaling line circuits for communication with addressable devices as required by the number of devices
   1. Each circuit shall consist of a two (2) wire circuit not requiring any end-of-line device for supervision. Each circuit shall accommodate up to sixty (60) intelligent initiating devices.
   2. Upon activation of any intelligent/analog device installed on the circuit, the system shall automatically report the status of the device and initiate the sequence of operations specified for that device. Alarms shall have priority over troubles.
   3. All intelligent/analog initiating devices on all circuits may be in alarm at the same time and perform the sequences of operation prescribed by the system configuration. If there

are more than 127 alarms, the message "more than 127 alarms" will appear and any alarms after 127 will still have all of their required functions performed.

4. The circuits shall detect a line break and provide information to the control panel allowing the user to determine between which two (2) devices the break has occurred.

R. Additional circuits for operation of DC audible devices, leased line, or city tie, shall be provided by a Signal Module. This module shall be system interconnected by a card edge connector, and shall be operable by the control unit.

1. Upon command by the control unit, the output circuits will respond as configured. The output current shall be at least 1.5 amps per circuit. Each circuit shall be fused separately and supervised.
2. Open circuits shall report trouble only and respond with circuit identification. A shorted circuit shall respond in a similar manner.
3. The module shall contain two programmable open collector outputs capable of sourcing 250 mA at 40 VDC for relay or LED activation.

S. Provide a controllable relay output module for control of air handling units and other building life safety functions.

1. The module shall be system interconnected by a card edge connector and shall be operable by the control unit or manually controlled.
2. It shall contain four independent relays, fitted with form "C" contacts, rated at 2 Amp 28VDC/120 VAC Resistive.

T. Cabinet: Provide a NEMA 1 cabinet to house all controls, power supplies, motherboards, relays, and accessories. Cabinet shall fit in space designated on the plans.

U. Network: Furnish and install fiber optic network cards for communication between Fire Alarm Panels. The network shall be so constructed that all devices shall continue to communicate even with a single fiber fault. (Class A operation)

1. Fiber Modules shall be located in the fire alarm panel in each area.
2. Fiber shall be continuous between the fire alarm control panels.

V. Programmer Tester: Furnish to the owner a portable handheld fire alarm system device programmer/tester equal to the FireFinder XLS DPU Programmer and Tester complete with a DPU-RPT carrying case. Furnish an operations manual for the programmer.

2.3 FIRE ALARM ANNUNCIATOR

A. Furnish and install Fire Alarm Annunciators (FAA) equal to the Siemens SSD-C series panel where indicated on the plans.

B. Each annunciators shall have the functions listed below:

1. LCD display with four lines of forty characters each.
2. Duplicate of command keys on the Fire Alarm panel to include:
   a. Acknowledge
   b. Silence
   c. Reset

C. Provide an FAA at the following locations at a minimum:

1. Building 1A Officer Station 106.
2. Building 1B Officer Station 106.

3. Building 2 Officer Station 109.
4. Building 3 Officer Station 106. (ADD Alternate)
5. Building 4 Central Control 102.
6. As indicated on the SE plans.

2.4 ALARM INITIATING DEVICES:

A. All intelligent/analog smoke and thermal detectors shall contain an integral alarm LED. All intelligent/analog detectors shall be individually identifiable from the control panel.

B. The intelligent/analog smoke detector shall be a plug-in, twist/lock unit which shall be capable of removal from or installation into its base with one hand.
   1. The detector shall contain two ionization chambers and solid state indicator lamp. The reference chamber shall compensate against sensitivity changes due to changes in environmental temperature, humidity and barometric pressure. The sensing chamber shall be open to the outside elements through a protective cover which will permit products of combustion to enter, while preventing foreign matter from entering and causing unwanted alarms.
   2. The intelligent/analog detector sensitivity shall be individually adjustable from the control panel. It shall also be possible to accurately measure the intelligent/analog detector's sensitivity from the control panel. Relative sensitivity measurements, providing no readout of discrete sensitivity, will not be considered as being equivalent.
   3. The intelligent/analog ionization detector shall be dynamically supervised, indicating a trouble condition at the control panel when the detector is unable to sense a fire condition due to both internal and external operating conditions or malfunctions.

C. Furnish and install protective guards on ceiling or wall spot smoke detectors located in youth accessible areas. Unit shall be the Shaw-Perkins Protection Steel Smoke Detector Guard model #SDG or equal, be UL listed and constructed of heavy-duty double wall 16 gauge steel. Holes shall be staggered between the double walls. Guard shall be secured with pin-torx style security fasteners.

D. Furnish and install wall spot smoke detectors equivalent to Siemens Model FDOT421.

E. Furnish and install wall mounted smoke beam detectors equivalent to Xtralis OSID beam detector. Provide OSI-90 Imager and OSE-SPW Emitter. All units shall be hardwired for power and installed in environmental housings. Provide wire guards equal to OSID-WG for all units.

F. The intelligent thermal detectors shall be of the rate compensated fixed temperature type. The intelligent thermal detectors shall be individually annunciated on the control panel. The intelligent thermal detectors shall contain an integral alarm lamp. The intelligent detector's address shall be set by electronic means only, no mechanical means such as programming pins, dipswitches or rotary dials shall be used.
   1. Furnish and install heat detectors equivalent to Siemens Model FDT421.

G. The intelligent interface module shall incorporate a custom microprocessor based, integrated circuit which shall provide communication with the XLS control panel. The interface module shall supervise and monitor normally open or normally closed dry contacts. The interface module shall report the contact's status to the control panel. The intelligent interface module shall be dynamically supervised and uniquely identifiable by the control panel. The intelligent

interface module's address shall be set by electronic means only, no mechanical means such as programming pins, dipswitches or rotary dials shall be used. The intelligent interface module shall be used to uniquely identify all water-flow switches, tamper switches and OS and Y valves.

H. The intelligent manual fire station shall be non-coded and shall operate on any addressable detection circuit. The intelligent manual fire station shall be individually annunciated on the control panel. Provide key activation option in youth areas. Operation of station requires the use of a special key. All manual fire alarm stations shall be identified with both English and Spanish verbiage.
   1. Furnish and install manual pull stations equivalent to Siemens HMS-S.
   2. Furnish and install manual pull stations with key activation equivalent to Siemens MSM-INST.

I. The non-addressable thermal detectors shall be either fixed temperature or rate compensated rating and type as indicated on the drawings. Non-addressable thermal detectors shall contain an integral alarm lamp.

J. The air duct detector shall operate on a cross-sectional air sampling principle to overcome stratification and the skin effect. The air duct detector shall consist of a standard intelligent/analog ionization detector mounted in an air duct sampling assembly and sampling tube that protrudes across the duct of the ventilating system. The air duct detector shall retain the features of the intelligent/analog or non-addressable ionization detector, and be installed in the ventilating duct as indicated in the manufacturer's instructions. Provide an air duct detector for all HVAC units with indicated as 2000CFM or larger.
   1. Furnish and install duct detector equivalent to Siemens FDBZ492-HR.

K. Addressable Modules: Furnish and install addressable modules as required. Addressable modules shall be equal to the following:
   1. HTRI-S, which provides a single addressable input to the fire alarm system.
   2. HTRI-R, which provides a single addressable input to the fire alarm system and a single output on the same address.
   3. HTRI-D, which provides two addressable inputs to the fire alarm system and requires two addresses.
   4. FDCIO422, which provides four addressable inputs and four addressable outputs.

L. Miscellaneous relays: Where fire alarm contacts are not large enough to handle the control current, provide larger relays and contactors mounted in NEMA 1 boxes.

2.5 ALARM INDICATING DEVICES:

A. The alarm horns shall be of the polarized 24 VDC type. The mechanisms shall contain an aluminum diaphragm, glued, tempered and polished armature, and tungsten contact points, all housed in a die-cast frame and grill assembly. The alarm horns shall be ADA approved. Provide candela ratings as required by code.
   1. Furnish and install horn strobe equivalent to Siemens ZH Series.

B. Alarm visual strobes shall be clear with a flash rate not to exceed two (2) flashes per second, nor less than 1 flash per second throughout the voltage range of the appliance. Source intensity not to exceed 1000 candela. Strobe appliances shall be ADA approved and listed under U.L. 1971.

1. Furnish and install strobe equivalent to Siemens ZR Series.

C. All strobe appliances shall be synchronized so that all strobes visible at a single point flash simultaneously.

D. Furnish and install a protective cover for each strobe or audio visual device located in youth areas. Unit shall be equal to STI model STI-1210C. Unit shall be UL listed and constructed of UV-stabilized polycarbonate.

2.6 FIRE DOOR HOLDERS

A. Furnish and install magnetic door holders equal to Siemens SDH-2 where indicated on the plans. Coordinate installation with all trades.

2.7 TRANSIENT SURGE SUPPRESSION

A. Acceptable manufacturers are as follows:
1. Northern Technologies Incorporated
2. DITEK
3. PolyPhaser Corporation
4. Transtector

B. Suppression: Provide surge protection for wiring that leaves the building. Provide Northern Technologies series PLP-s units matched to the voltage of the circuit suppressed. The suppressors shall have a peak pulse power dissipation rating of 10 joules each mode, minimum.

C. System Power: Provide surge protection for 120 power connections both inside and outside the building. Devices shall be equal to Northern Technologies TCS-HWR series rated for the power of the circuit suppressed. The suppressors shall have a peak pulse power dissipation rating of 300 joules L-N, minimum. Units shall provide a dry contact monitored by the security system and identified by electrical panel circuit number

2.8 CABLING AND WIRE

A. Acceptable manufacturers:
1. Liberty Wire and Cable
2. Eastman Wire & Cable
3. West Penn Wire
4. Belden
5. Carol
6. General Cable
7. Clifford of Vermont, Inc.

B. Wire Size: Furnish and install sufficient wire gauge to limit voltage drop to 5%.

C. Initiating device wiring: Furnish and install data grade fire alarm cabling to all addressable devices equal to West Penn D975 #18 twisted shielded pair. AQ224 for wet rated use.

D. Alarm Indicating Appliance Circuits: Wiring for signal circuits, power, and miscellaneous controls shall be a minimum of #14 THWN.

E. Cable shall be wet rated when placed in conduit buried under ground.

2.9 FABRICATION

A. Assemble and Test: Assemble all smoke detectors and annunciating devices so that they are addressed according to the prints.

B. Device Identification: Identify smoke detectors and annunciating devices with the loop address assigned according to the prints. Label should be visible after detector has been placed into the base.

PART 3 - EXECUTION

3.1 COORDINATION

A. Preliminary Coordination: Coordinate all required embeds, block-outs, and construction as required by the plans.

B. Coordination with the Authority Having Jurisdiction (AHJ): Contractor shall submit plans and pay for all Fire Alarm permits. Contractor to notify the General Contractor and Architect immediately if the AHJ requires something more than what is shown on the contract documents. This notice is to be written and include any AHJ written comments as well as a price for additional fire alarm material.

3.2 INSTALLATION

A. Wire: Install all wire according to be the following:
   1. In strict compliance with manufacturer’s specification.
   2. In full compliance with 2013 CEC, 2013 NFPA 72 requirements.
   3. Transposing or changing color coding of wires shall not be permitted.
   4. All conductors in conduit containing more than one wire shall be labeled on each end with "E-Z markers" or equivalent.
   5. Conductors in cabinets shall be carefully formed and harnessed so that each drops off directly opposite to its terminal.
   6. Cabinet terminals shall be numbered and coded. All controls and function switches shall be clearly labeled on all equipment panels.
   7. Wire Termination: All wiring shall be terminated at both ends and uniquely labeled in accordance with the equipment wiring plans. Wire not energized or connected to active devices shall be labeled for future use.

B. Panels: Control and other panels shall be mounted with sufficient clearance for observation, service, and testing. All fire alarm control panels must be clearly marked for easy identification.

C. Junction Boxes: All fire alarm junction boxes must be clearly marked for easy identification.

D. Flexible Connectors: Flexible connectors shall be used for all devices mounted in suspended lay-in ceiling panels. Flexible connections shall be securely supported by the building structure and limited to a maximum of three feet.

E. Continuous Grounding: All conduit, mounting boxes, junction boxes and panels shall be securely hung and fastened with appropriate fittings to insure positive grounding throughout the entire system.

F. Shared Raceway: No wiring other than that directly associated with fire alarm detection, alarm or auxiliary fire protection functions shall be permitted in fire alarm conduits.

G. Splices: Wiring splices are not acceptable between devices. Electrical boxes provided are to be used as pull points, not junction points.

H. Wire Quality: All wiring shall be checked and tested to insure that there are no grounds, opens or shorts.

I. Listing: All wiring and raceways shall be listed for the intended installation and installed in strict accordance with the National Electric Code as required by the conditions of where it is stalled. This includes but is not limited to ratings for riser, plenum, or wet installations.

J. Licensed Electrician: All fire alarm systems shall be installed under the supervision of a C-10 License.

K. Coordination: Fully coordinate all equipment installation with division 23 and division 26 contractors.

L. Manual Pull Stations: Install per code and at a minimum as follows:
1. Public Areas: Install within 5 feet of the door at each means of egress with no further than 100’ travel distance.
2. Youth Housing Units: Locate manual stations at the Office Control stations and not at the means of egress where youths can tamper with the stations.
3. Youth areas: Where indicated provide manual stations with key activation equal to Siemens MSM-INST.
4. Bilingual stations are required.

M. Spot Smoke detectors: Install per code and at a minimum as follows:
1. Where a single detector is shown on the wall, locate top of the detector 12” from ceiling in accordance with NFPA 72. Fully coordinate with all other trades. Locate no closer than 3’ to any HVAC exhaust registers.
2. Where a single detector is provided on the ceiling, locate in the center of the room. Fully coordinate with all other trades. Locate no closer than 3’ to any HVAC exhaust registers.

N. Seismic: The entire system shall be installed to meet the seismic requirements for the area.

3.3 SOFTWARE

A. For each Fire Alarm Control Panel, furnish to the owner uniquely identified:
1. One (1) copy of the programming and source code of the application software on a CD or DVD. This copy shall have all programmer comments, variable names, and mnemonics included.
2. One (1) separate back-up CD or DVD for each FACP with the ladder logic file (programmer’s notated file) and the source code. Each disk will be labeled with the project name, programs, FACP, programmer, and revision date.

B. Furnish a single Adobe Acrobat PDF file detailing all passwords for each FACP. This file shall also identify the following by system and panel:
   1. The file name of each program required for restoration of each failed FACP.
   2. The passwords required for each FACP as well as required programs.
   3. The name of the programmers for each custom program.
   4. The date of the last program change.
   5. Furnish documents listed in 3.4 A-B at project completion. Furnish a new set with all revisions after the completion of 280500, 1.9-C.

3.4 SPARES

A. Turn over the owner all programmer/testers for system maintenance including programmers for addressable devices and beam detector test equipment.

B. Turn over to the owner devices in their original shipping boxes with the part number and description of each device contained. Turn over to the owner spares as follows:
   1. 10 Spot smoke detector heads.
   2. 2 Beam detector transmitters and 2 beam detector receivers.
   3. 10 Audio-Visual units.
   4. 10 Visual-Only units.
   5. 2 Duct smoke detector heads.
   6. 2 Addressable input modules.
   7. 2 Addressable output modules.
   8. 2 Addressable pull stations.
   9. 10 keys for key operated stations.
   10. 20 spot smoke detector dust covers for use by the owner when they are performing cleaning tasks that are known to cause nuisance alarms.

3.5 FIELD QUALITY CONTROL

A. Test and Certification: The contractor shall perform all electrical and mechanical tests required by the equipment manufacturer's certification form. In addition, they shall measure and adjust each of the analog detectors to the sensitivity setting appropriate to the area. This must be performed with the detector at its installed location under normal environmental conditions. Bench settings are not acceptable. All test and report costs shall be in the base price. Technicians shall complete the NFPA 72 fire alarm certification report and submit copies to the owner and the engineer.

B. Final Test: Final tests and inspection shall be held in the presence of architect's representatives and to their satisfaction. The contractor shall supply personnel and required auxiliary equipment for this test without additional cost. Final test to be witnessed and approved by the AHJ.

END OF SECTION 28 3111

SECTION 284600 – TOUCHSCREEN CONTROL STATION

PART 1 - GENERAL

1.1 SUMMARY

A. Scope of work: Furnish and install all components for a Touchscreen Control Station (TCS) integrated with security systems as indicated on the plans and described herein. The Touchscreen Control Station shall be the primary operator interface.

B. The ESC as defined in Section 280500 Common Work Results for Electronic Safety and Security shall be responsible for providing and coordinating this system.

1.2 SYSTEM DESCRIPTION

A. Touchscreen Control Station (TCS): The Touchscreen Control Station shall be a computer terminal with the appropriate cards and programming incorporated into an integrated unit to serve as an operator interface. Refer to Specification section 284600.1 for the operations controlled by each TCS station.

B. Basic Operation: All areas of the building will be graphically represented displaying all monitored and controlled icons as required for proper operation. The graphics for the TCS shall fit the screen size, configuration and icon functions as described below. **The orientation/direction of each map must match the orientation as related to the operator at each TCS station location.**

C. Task Groups: Control and monitoring functions shall be assigned to a TCS through task groups. A task group is a logical association of points assigned to a particular TCS where multiple TCS units are provided in a single control room. Assigning a task group to a particular TCS will prevent that point from being controlled by another TCS.

D. Graphic Plans: The TCS uses graphic representations of various facility areas to describe events as they occur. Each graphic is to be a 1/8” scaled depiction of each area. Graphics are to be sized for proper operation of control icons and useful building representations. All graphic screens shall be labeled as detailed in this section.

1. Key Plan: A facility key plan will be available on all graphic screens. Selecting an area of the key plan will call up a graphic of the area providing control icons and more detailed building information. Icons as described below will be located on the plan to graphically locate where in the facility the controlled item is installed. The area plans are the second level of graphic zoom.
2. Detail Window: Detail plan windows shall be provided for any section of the graphic plan where there is a high concentration of controls making it impossible to properly indicate all icons. This shall be the third and last level of graphical zoom.

E. Provide the following:

1. TCS.1A Officer Station 106 in Building 1A
2. TCS.1B Officer Station 106 in Building 1B
3. TCS.2 Officer Station 109 in Building 2
4. TCS.4A Central Control 102 in Building 4

5. TCS.4B Central Control 102 in Building 4

1.3 GLOBAL FUNCTION OPERATIONS

A. All electrically controlled hardware and security subsystems end-of-line devices as indicated herein shall provide status and control by use of symbolic icons and status indicators. All control icons (switch functions) that are used shall be of a size that will facilitate a positive selection point; the minimum size of 0.5 inches square shall be required. All status indicators shall be a minimum of three-sixteenths inch in diameter or a large, square or rectangle symbol may be used at an equal size. All symbols shall provide status by its color and/or associated text, both the control icons and its associated status indicators. Global function icons shall be located on the bottom of each graphic screen. These icons, if active, shall control global functions for the associated graphically displayed area.

B. Log-on: Selecting this icon shall cause a pop-up window to appear. Located within this window there shall be a text prompt requesting the operator to enter their password and user name. The system shall confirm the password and username. If they match the stored list of usernames and passwords, the system site screen shall be displayed and a valid log on event shall be recorded on the event recorder and data log. The operator will then have access to those functions assigned to entered username and password. If the username and password do not match the stored list of usernames and passwords, the system shall display a text window with “Log On Failed” and return to the main log on screen. The failure will be stored as an event on the event recorder and data log.

C. Log-off: Selecting this icon shall cause a pop-up verification window to appear on top of the graphically displayed area. Located within this window there shall be a text prompt requesting the correction officer if they wish to proceed with the Log Off function. Also located within the window shall be two icons. One shall have the text “YES” and one shall have the text “NO”. Selecting the icon with the text “NO” shall cause the verification window to be removed from the screen and the system shall return to normal operation. Selecting the icon with the text “YES” shall cause the verification window to be removed from the screen and shall cause the current operator to be logged out of the TCS. The display shall return to the primary log-on screen awaiting a new operator to log-in on this console.

D. Identifying Graphic Screen labels TCS graphics screens shall have labels for the following critical areas at a minimum:
1. Cells
2. Control rooms
3. Electrical/Security Electronics rooms
4. Communication rooms (IDF/MDF)
5. Mechanical rooms
6. Dayrooms
7. Intake
8. Medical
9. Vehicle sallyport
10. Admin. areas

E. TCS graphics and labels shall be provided for all devices including:
1. Controlled doors
2. Monitored Doors
3. Intercoms

4. Site gates
5. Cameras
6. Duress stations
7. Loop Detectors

F. TCS system screens shall include the following features:
1. Each identifying label shall have a fixed value that may be used for programming and cannot be changed by the operator.
2. Each identifying label shall have an alternate value provided by the owner. This field shall be up to 10 alphanumeric characters long, cannot be used for programming purposes and can be changed by the owner with the proper password.
3. Provide a toggle on the utilities screen to toggle between the two label sets.
4. The initial alternate labels shall be programmed by the contractor as approved by the owner.
5. The selected label shall be a part of the point identifier when listed on the screen or logged for reporting.
6. The utility screen shall allow the operator to print a list of points with both labels.

1.4 SYSTEM UTILITIES

A. Selecting this icon shall cause the system to switch to the System Management Screen. The functions located on this screen will be based upon the access level that the current operator has obtained. Specialized functions will be disabled and grayed out if the access level is not acceptable. The Systems Management Screen shall consist of, but are not limited to these functions:
1. Configure Users
2. Change Password
3. TCS Calibration
4. Set Date and Time

B. The system utilities operation shall be menu driven with an instructive help-menu.

1.5 SITE PLAN

A. Selecting this icon shall cause the system to display a graphic screen, which displays the entire site plan.

1.6 AREA MAPS

A. Selecting this icon shall cause the system to display a graphic screen, which displays the entire area in which the system is viewing at that time. This is to allow the operator a quick method to access another detail section within that area.

B. Task group assignment shall be accomplished through the area maps. Task group assignment shall be activated by enter the correct password on any central control TCS.

1.7 TCS SCREEN COMPONENTS

A. Active Graphic Screen: The Active Graphic Screen shall display the active part of the building with the appropriate icons and status indicators. This shall be where most of the operator to system interface occurs. Maximize this area for each screen.

B. System Alarm Control: There shall be an area of the Active Graphic Screen that displays the highest priority system alarms. Display a minimum of four events simultaneously. The operator shall be able to scroll through all active alarms. There shall not be any limitation on the number of active alarms that a TCS can display. As each alarm is processed, corrected, or reset, it shall be removed from the System Alarm Line.

C. Intercom Control: Intercom calls shall be displayed on a separate area from alarms. Display a minimum of four calls with the ability to scroll through all active calls. Refer to the intercom section of this specification for additional information. There shall not be any limitation on the number of active intercom calls that a TCS can handle. As each call is processed or reset, it shall be removed from the Intercom Control area.

D. Pop-up Window: A pop-up window is a graphic that is displayed when a particular event occurs. Refer to the description and function for each item for additional information.

E. Icon: An Icon is a graphic that is displayed whenever the appropriate screen is called. Refer to the description and function for each item for additional information.

1.8 LOCKING OPERATIONS

A. Door Position Status Icon (Monitored Only):
1. Description: The Icon shall consist of a **circular** figure with a door graphic that indicates that the door is secured via a color change. This icon shall be visible whenever the screen is selected.
2. Function: The Door Position Status Icon background shall illuminate red when the door is unsecured and shall be gray when the door is secured. In addition, graphically depict that the door is closed when secured and open when unsecured.
3. Distribution: Provide an icon for each monitored only door on each screen.
4. Alarm: Since these are used for security electronics rooms, pharmacy, and records rooms, the opening of this door shall register an alarm on the TCS alarm line of the active screen.

B. Interlock Group Status:
1. Description: A yellow circle with a yellow line to each door that is part of the interlock group. In the center of the circle shall be a number. The number shall be “0” when not in interlock override. This icon shall be visible whenever the screen is selected.
2. Function: When the interlock override is active, the counter will count down from 10 to 0 seconds. Anytime during this timer period, doors in the interlock group may be unlocked.
3. Distribution: Provide an interlock group status for each set of interlocked doors shown on the screen.

C. Interlock Override Icon:
1. Description: A pop-up verification window with the text prompt, “YOU ARE ABOUT TO OVERRIDE A SECURITY INTERLOCK GROUP, ARE YOU SURE”. Also located within this window there shall be two icons, one shall have the text “YES” and one shall have the text “NO”. This Icon shall be visible only when an operator attempts to override a security interlock group.
2. Function: A pop-up verification window shall appear whenever a door in an interlock group is unlocked and a second door is selected. Selecting the icon with the text “NO” shall cause the verification window to be removed from the screen and the system shall

return to normal operation. Selecting the icon with the text "YES" shall cause the verification window to be removed from the screen and shall cause the indicator within the Interlock Override Function icon to change to count down from 10 to 0. When the override time limit is reached, the system shall return to normal.

3. Distribution: Provide Interlock override icons for each interlock group on the screen.

D. Swing Door Icon:

1. Description: The Swing Door Icon shall consist of a square button with a swing door graphic that indicates that the door is secured by both graphic change and color change. The button shall appear raised and appear to depress when clicked to unlock the door. Unlocking a swing door shall be a **single button** command **except at high security risk doors.** This shall have a **two-step** unlock function. Provide a pop-up verifying that you are about to unlock a high security door.
2. This swing door icon shall be visible whenever the screen containing the swing door is selected.
3. Function: Selecting the icon will depress the button and apply power to unlock the related door. The Swing Door Icon background shall illuminate red when the door is unsecured and shall be gray when the door is secured. In addition, graphically depict that the door is closed when secured and open when unsecured.
4. Distribution: Provide an icon for each controlled swing door on the each screen. Provide a monitoring icon for any controlled doors that are not controlled from the screen.

E. Cell Door Icon:

1. Description: The Cell Door Icon shall consist of a square button with a swing door graphic that indicates that the door is secured by both graphic change and color change similar to the Swing Door Icon. The button shall appear raised and appear to depress when clicked to unlock the door. Refer to specification 284600.1, "Control Matrix".
   a. Typical Cell door (Keyed Only): Local and central control stations will have monitoring status indication. If cell door control is disabled, no cell door shall be controlled from any control station.
      1) Local Control Station: Monitoring indication only (cell and circulation).
      2) Central Control Station: Cell door control is a control function that is password protected only. If the correct password is entered, the cell door control function will be activated.
      3) On a utility screen, provide an icon stating "CELL DOOR CONTROL". Selecting this icon will activate a pop-up window to enter the password. When the correct password is entered, controls will be enabled or disabled. The password shall be alphanumeric and have at least one upper case alphanumeric letter, one lower case alphanumeric letter, and one number. The password shall be at least 8 characters long.
   b. Segregation/Maximum Cell Door: Provide **Two step unlock** function with the cell door number within the pop-up. Provide a pop-up verifying that you are about to unlock this door. This icon shall be visible whenever the screen is selected. Provide the Segregation cell door number in the pop-up window for each individual cell door when door icon is activated.
2. Function: Selecting the icon will depress the button and apply power to unlock the related door. The Swing Door Icon background shall illuminate red when the door is unsecured and shall be gray when the door is secured. In addition, graphically depict that the door is closed when secured and open when unsecured.

3. Distribution: Provide an unlock icon for each controlled swing door as indicated in the Control Matrix. Provide a monitoring status icon for any controlled doors that are not controlled from the screen. Refer to specification 284600.1, “Control Matrix”.

F. Vehicle Gate Icon:
1. Description: The Vehicle Gate Icon shall consist of three **square** buttons for each gate. The buttons shall be labeled “OPEN’ STOP” and “CLOSED” in black text on a gray background and perform the indicated function. The button shall appear raised and appear to depress when clicked to open the gate. There shall be a separate icon that indicates the Vehicle Gate is secured by both graphic change and color change. This icon shall be visible whenever the screen is selected.
2. Function: Selecting the “OPEN” icon will depress the button and apply power to open the gate. Selecting the “STOP” icon will depress the button and remove all power from the gate. Selecting the “CLOSE” icon will depress the button and apply power to close the gate. The Slider Icon background shall illuminate red when the door is unsecured and shall be gray when the door is secured. In addition, graphically depict the slider gate as closed when secured and open when unsecured. Clicking the button a second time shall apply power to the close function of the slider.
3. Distribution: Provide a vehicle gate icon for each controlled vehicle gate on the screen. Provide a monitoring icon for any controlled doors that is not controlled from this screen.

G. EMERGENCY RELEASE:
1. Description: Provide a separate screen for the EMERGENCY RELEASE functions for the facility. Provide an icon for each area with “EMERGENCY RELEASE” in black text on gray background. This icon shall be visible on the TCS only when the screen is selected. When active, the background will change from gray to red and flash.
2. Function: Selecting this icon shall cause a pop-up verification window to appear on top of the graphically displayed area. Located within this window there shall be a text prompt requesting that the operator confirm the request before proceeding with the text “You have requested to unlock ALL doors in this area, ARE YOUR SURE?” Also located within this window there shall be two icons, one shall have the text “RELEASE” and one shall have the text “CANCEL”. Selecting the icon with the text “CANCEL” shall cause the verification window to be removed from the screen and the system shall return to normal operation. Selecting the icon with the text “RELEASE” shall cause the verification window to be removed from the screen and shall hold all locks in the area open, other than enclosed control rooms. Control rooms are not to be released upon selection of emergency release. The emergency release button shall flash and an audible and visual indication shall be displayed on the TCS in the area released. If the verification window is not confirmed after 5 seconds, the function shall automatically cancel and the system shall return to normal. To reset the emergency release, select the flashing “Emergency Release” icon and select “CANCEL” on the verification window. The Emergency Release function shall override all group assignments, interlocks, and other programming features that would exclude a door from opening under normal operations. Emergency release is a staggered function in that doors are released in groups of three, not all doors simultaneously. **The emergency release function in a selected smoke zone releases all controlled doors except a control room door within 60 seconds.** If the emergency release is canceled before the staggered cycle completes, the system shall discontinue unlocking doors and shall relock the doors previously unlocked.
3. Distribution: There shall be one emergency release icon for each area at a minimum and for each building.

4. ESC to include in their bid the cost to modify the Emergency Release programing following the final testing, as directed by the owner/engineer.

H. High Security Risk:
1. Description: A pop-up window to appear on top of the graphically displayed area with the text “HIGH SECURITY RISK”. Located within this window there shall be a text prompt “You have requested to unlock an EXTERIOR door in this area. ARE YOUR SURE?” Also located within this window there shall be two icons in the, one shall have the text “RELEASE” and the other shall have the text “CANCEL”. This Icon shall be visible only when called for under ‘Function’.
2. Function: Selecting an unlock icon to unlock an exterior door shall cause a pop-up verification window as described above to appear. Selecting the icon with the text “CANCEL” shall cause the verification window to be removed from the screen and the system shall return to normal operation. Selecting the icon with the text “RELEASE” shall cause the verification window to be removed from the screen and unlock the selected door. If the verification window is not confirmed after 5 seconds, the function shall automatically cancel and the system shall return to normal.
3. Distribution: Refer to Specification section 284600.1 Control Matrix.

I. DOOR OPEN TOO LONG Icon:
1. Description: A pop-up window with black text on a red back ground with a leader line to the appropriate door. Multiple leader lines can identify multiple doors or a separate pop-up can be programmed for each depending on program simplicity. This Icon shall be visible only when called for under ‘Function’.
2. Function: The status icon, which will illuminate and flash red with an audible tone to indicate a security door, is opened too long. Selecting the silence icon shall silence the audible tone and illuminate the status icon a steady red. The status icon shall disappear when the security door returns to normal operation.
3. When a circulating door is opened, a timer will start on the PLC. If the door is not secured before the timer expires, then a ‘Door Open Too Long’ alarm will sound at central control and register on the alarm line.
4. The alarm event will be recorded with Door ID Time and Date.
5. Securing the door will automatically reset the timer. If the alarm has already been activated, then securing the door will clear the alarm and no other operator action is required.
6. Central control can acknowledge the alarm and allow it to continue as allowed by Operations policy and procedures. If the ‘Door Open Too Long’ alarm is acknowledged and allowed to continue unsecured, then the alarm will resound at central control in 15 minutes.
7. Each circulating door shall have its own unique timer.
8. The ‘Door Open Too Long’ alarm function will be suspended during Emergency Release since doors are supposed to be held open until Emergency Release is canceled. Once canceled, door open timers will start for all doors not secured.
9. The timer alarm function shall not apply to cell doors.
10. Doors that are provided with a door position switch and only monitored, but not controlled will also be provided with ‘Door Open Too Long’ timers.
11. All information above will be stored as part of the SQL database.
12. Distribution: Provide a status icon on the computer control station screen to indicate that security doors used for circulation or monitored only are opened and have not been secured within a preset time value ranging from 0 to 999 seconds.
13. Alarm: This condition shall register an alarm on the TCS alarm line of the active screen.

J. CHANGING THE TIMER VALUES

1. The TCS will provide a utility screen to enter all timer values for all doors described in the form of a graphic map. The graphic map will be the same map used for door control and annunciation with the timer value displayed at each door.
2. Only the Administration access level password can change the timer values.
3. Operator level users cannot change the timer values.
4. The timer value will range from 0 to 999 seconds.
5. The utility screen will keep a running average of the length of time each door remains open to aid in door timer management.
6. The utility screen will provide a 'Copy to All' function to copy a timer setting to all timers currently displayed on the screen.

K. DOOR KEYED 'ALARM'

1. Exterior and circulating doors are not to be keyed open. There shall be an alarm generated in central control when a circulating door is opened by any means other than a command from the PLC.

2. Provide a status icon on the computer control station to indicate security doors used for circulation or monitored doors that have been opened by a door key. Selecting the silence icon shall silence the audible tone and illuminate the status icon a steady red. The status icon shall disappear when the security door returns to normal operation.

1.9 INTERCOM OPERATIONS

A. Intercom Control Queue: There shall be a group of control icons used to select, answer and reset audio communications between an intercom and the TCS. This group shall be as follows:

1. Description: Provide a call list or Queue that identifies as a minimum the last four calls with the call time for each. Provide controls to scroll up of down through the Queue. Provide a "CONNECT" icon, a "GO TO NEXT" icon and a "DISCONNECT" icon as a minimum.
2. Function: Queue shall be sized to display a minimum of four active calls. There shall be no limit to the number of calls allowed in the system on a TCS.
3. Distribution: Provide an intercom Queue on each TCS.

B. Intercom Station Call:

1. Description: Provide a speaker symbol on a button.
2. TCS operator Function: Selecting an intercom station icon shall open a talk path between the operator's TCS and the associated intercom station. The intercom icon shall illuminate yellow. There shall be no audible tone at the field intercom station allowing the TCS operator to covertly listen to the station. The TCS operator can activate the press-to-talk switch on the microphone to speak to the station. Selecting the intercom station icon a second time shall close the talk path and the status icon shall extinguish.
3. Station call-in Function: Pressing the field call station button shall annunciate at the controlling TCS by flashing the associated field intercom icon in alternating colors with an audible voice annunciation stating "Intercom call." Selecting an intercom station icon shall open a talk path between the operator and the associated intercom station. The associated status icon shall illuminate yellow. Selecting an intercom station icon a second time shall close the talk path and the status icon shall extinguish.
4. Distribution: Provide an icon for each intercom station.

C. Officer Station to Control Room Communications: Same as intercom station to TCS operation described above.

D. Rollover: Once an intercom call button has been pressed, the PLC will start a timer. If after 10 minutes an intercom has not been answered by the local station assigned the intercom task group, Central Control will be alerted that the intercom has been unanswered.

E. Call Button:
1. Description: Provide a round icon for each call button. Icon shall be gray under normal operation. When call button is pressed the icon shall turn YELLOW in color and remain yellow until the reset button has been activated as to clear the call.
2. All call buttons shall be logged on the ERC system.
3. Distribution: Provide round icon on TCS station.

1.10 AUXILIARY OPERATIONS

A. General Alarm Condition: There shall be a status icon, which will illuminate and flash red with an audible tone to indicate a device initiated alarm condition. Selecting the silence icon shall silence the audible tone and illuminate the status icon a steady red. The status icon shall disappear when the device returns to normal operation. The following conditions are able to initiate general alarm conditions.
1. Emergency Power Status
2. Staff Duress Status
3. Controller Fault

B. Synchronized Digital Clock System: Provide a digital clock on all TCS's. The digital clock shall be a minimum of 0.5 inches high by 1.25 inches long. The digital clock shall have the capability of displaying both twenty-four (24) hour (military time) and twelve hour formats. Mode and time settings will be through the system utilities function. Accuracy of the synchronized digital clock system shall be within +/- one (1) minute within a thirty (30) day period.

C. Staff Duress System: Activation of a duress station will cause:
1. Annunciation on the central control TCS.
2. A red icon to appear and an audible tone will sound.
3. If there is a local TCS, the TCS will be shut down.
4. Central control will have to reactivate the local TCS once the station has been reset.
5. Each activation will be logged on the central control event recording system (ERC).
6. Camera associated shall automatically call up.
7. Provide a duress icon on each local TCS. This should be located at the top right hand side of the screen. This will function the same as a duress station mounted on the wall.

D. Enable/Disable Function:
1. Provide an icon on the Central Control TCS to enable/disable any local TCS. This should be located in each control room or location of the TCS on the map. This will log on the ERC each time this function is activated.

E. Telephone Disconnect:
1. Description: Provide a black outline of a telephone on a gray button that appears raised. When activated, the back ground shall change to yellow.

2. Function: Clicking on the telephone icon shall depress the button and change the background to yellow and disconnect the youth telephones as well as placing a red slash through a circle over the telephone symbol. Clicking it a second time will cause it to return to normal and activate the youth telephones.
3. Distribution: Provide a telephone disconnect icon on the ground level of each dayroom.

F. Door Alarm Shunt Icon:
1. Description: Provide a gray button with “Door Alarm Shunt” in black text. The button shall appear to be raised.
2. Function: Clicking on the "Door Alarm Shunt" shall cause the button to momentarily depress and silence the audible "Door Open to Long" or "Door Keyed Open" alarm. The visual indicator shall remain.
3. Distribution: Provide one Door Alarm shunt for each door on an Administrator password protected screen.

G. Fixed Camera Call-Up:
1. Description: Provide a black outline of a camera on a gray button. When activated, the background shall change to blue. The camera should graphically match the orientation of fixed cameras.
2. Function: Clicking on the camera icon shall, change the background to blue, and display the camera video on the spot monitor associated with the TCS displaying the camera.
3. Distribution: Provide a Fixed Camera Icon for each camera controlled from the TCS.

H. Pan-Tilt-Zoom Camera Call-Up:
1. Description: Provide a black outline of a camera on a gray button. Provide icons to select preset positions 1 through 8 around the camera icon. When activated, the background shall change to blue. The presets should match the views from the camera as close as practical.
2. Function: Clicking on the camera icon shall, change the background to blue, and display the camera video on the spot monitor associated with the TCS displaying the preset view #1 camera. Selecting other presets will display those presets accordingly. Program a position for each of the 8 preset icons.
3. Distribution: Provide a Pan-Tilt-Zoom Camera Icon for each Pan-Tilt-Zoom camera controlled from the TCS.

I. Silence Icon:
1. Description: Provide a gray button with “SILENCE” in black text. The button shall appear to be raised.
2. Function: Clicking on the silence icon shall cause the button to momentarily depress and silence the audible tone. The visual indicator shall remain. Alarms from duress stations cannot be silenced until they are reset at the device.
3. Distribution: Provide one silence icon on each screen.

J. Reset Switch:
1. Description: Provide a gray button with “RESET” in black text. The button shall appear to be raised. .
2. Function: Clicking on the reset icon shall cause the button to momentarily depress. Silenced alarms shall be cleared from the system. Duress station alarms cannot be reset until they are reset at the station alarming device.
3. Distribution: Provide one reset icon on each screen.

K. System Utilities
1. Selecting this icon shall cause the system to switch to the System Management Screen.
2. Provide controls to set the time and date.

L. UPS System Alarms:
1. UPS alarm shall be a pop-up window generated in central control TCS, display in the alarm queue and will have an audible tone to indicate a device initiated alarm condition (refer to Specification Section 280500.1). Provide the UPS initiated alarm conditions as listed below:
    a. UPS Active or 120 VAC Power Failure
    b. Low Battery.
    c. Low Voltage.
    d. Inverter Power.
    e. Trouble.
2. Selecting the silence icon shall silence the audible tone. The status shall disappear when the device returns to normal operation.
3. This will log on the ERC each time this function is activated.

M. PLC Network Communication Alarms:
1. PLC network alarm shall be a pop-up window generated in central control TCS, display in the alarm queue and will have an audible tone to indicate a device initiated alarm condition (refer to Specification Section 284619, 2.1, C). Provide the PLC network initiated alarm conditions as listed below:
    a. Communication Failure.
    b. Communication Power Failure.
2. Selecting the silence icon shall silence the audible tone. The status shall disappear when the device returns to normal operation.
3. This will log on the ERC each time this function is activated.

N. TVSS Alarms:
1. TVSS alarm shall be a pop-up window generated in central control TCS, display in the alarm queue and will have an audible tone to initiate a device initiated alarm condition (refer to Specification Section 284619, 2.5). Provide the TVSS initiated alarm conditions as listed below:
    a. 120 VAC TVSS (Failure).
    b. 208 VAC TVSS (Failure).
2. Selecting the silence icon shall silence the audible tone. The status shall disappear when the device return to normal operation.
3. This will log on the ERC each time this function is activated.

O. Priority levels:
1. The system shall provide 25 levels of alarm priorities. Alarms and events shall be displayed by priority.
2. All alarm points shall be logged to the Alarm Log with the following minimum information:
    a. Time and date of alarm activation
    b. Alarm point name (Owner configured)
    c. Time and date of acknowledgment
    d. Time and date of reset
    e. Operator handling alarm

1.11 TASK GROUP

A. Definition: A task group is a logical grouping of points that can be assigned to multiple TCS stations. Refer to Specification Section 284600.1 Control Matrix for Task Groups.

1.12 IP VIDEO OPERATION

A. All cameras shall be displayed on the Central Control TCS stations only. These shall be by room location and camera number.

B. Activating the associated icon will call up the appropriate camera on the spot monitor for viewing by the operator.

C. Camera monitoring intercom stations shall automatically display on the spot monitor when the intercom station is selected at the related TCS.

D. Owner to provide camera titling prior to final programming of the camera and monitor system.

1.13 VOICE ANNOUNCE

A. The TCS shall provide a voice announcement of the following events. The announcement is by event type not by point as follows:
1. Intercom calls to the TCS shall be preceded by a voice announcement "Intercom Call."
2. Duress Stations shall be preceded by a voice announcement "Duress."
3. Call button shall be preceded by a voice announcement " Incoming Call."
4. Emergency release caution windows shall be annunciated by "Warning! You are attempting to open all the doors in the area. Escape is possible. Please confirm."
5. Interlock override caution windows shall be annunciated by "Warning! You are attempting to override a security sally port. Escape is possible. Please confirm."

1.14 DIRECT SUPERVISION

A. The Housing unit TCS will be operated as direct supervision units.

B. The Housing unit TCS shall time out if there is no activity.

C. The Housing unit TCS shall have a TCS disable function which, when selected, disables the TCS.

D. Intercoms shall be controlled from central control when the TCS is disabled.

E. Provide a duress icon on the TCS such that when activated the TCS will shut down and alarm in central control.

1.15 SUBMITTALS

A. Provide basic submittals as required by Section 280500 Common Work Results for Electronic Safety and Security and by the General Contract requirements.

B. In addition, submit color prints of all graphic screens for approval.

C. Also submit a list of all reportable alarm points.

D. Submit a flow chart or site map showing the relationship of all proposed screens.

1.16 SYSTEMS INTEGRATION

A. Integrated Systems:
1. IP Video System.
2. Door locking control system.
3. Intercom system.
4. The PLC system.
5. UPS system.
6. Card Access systems

B. Event Priority Level: The operator shall always have control and can manually activate any icon displayed at any time. The following priority applies only to the automatic call up of events for the system and the "Select" icon described above under Interactive Alarm/Audio Handling and Operation. Events shall be given the following priority:
1. Staff Duress Alarms
2. Perimeter system alarms
3. Intercom Calls
4. Door alarms,
5. Communication failure alarms
6. Transient Voltage Surge Suppression Troubles

1.17 TCS CONTROL AND MONITORING SYSTEM:

A. Provide and program all necessary TCS selection zones and required graphic lay-out displays on the different monitors to control specified devices as follows:
1. The system shall be capable of changing to a called screen within one second.
2. The system must generate a command from the TCS to the remote PLC within 500 milliseconds of receiving the selection on the screen.
3. The TCS shall be updated with point status from the PLC every 500 milliseconds.
4. Failure of a TCS shall not disturb PLC communications with other control consoles.
5. The TCS system shall have a means to prevent image burn-in on the CRT when the system control panel has been inactive for more than 2 minutes. Any movement of the trackball should return to the last active screen.
6. Access to the TCS system shall be password protected and all operators shall log into the system. The system shall allow for a minimum of 16 different access levels. Users can log in from a keyboard or directly on the screen.
7. Data Logging: All alarms and critical actions are recorded to the hard drive.
   a. Critical actions initiated at any station are reported to the data logging system. Such reports shall consist of a time and date tag, activity description, station tag and the operator logged on to the system. Special alarms and conditions shall be reported in a similar manner. Critical actions are defined as follows:
      1) Duress alarm activation.
      2) Transient Voltage Suppressor failure on protected 120 VAC security circuits.
      3) Emergency Release activation.
      4) Refer to specification section 284600.2 for other actions to be logged.
   b. The data logging system shall maintain and store files from which reports may be generated. The Data Logger shall purge old files after a preset time.

c. The log files will be stored on the hard drive and kept for a predetermined amount of time. The owner shall have the option to archive data files to CDs.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Acceptable Manufacturers
1. Accurate Controls, Ripon, WI; 920-748-6603.
2. CMLRW Security, Erie, CO; 720-466-3650
3. Cornerstone Detention, Decatur, Alabama 256-560-4207.
4. Com-Tec Security, Inc., Appleton, WI; 920-749-2840.
5. Metroplex, San Antonio, TX; 210-495-5245.
6. Sierra Detention Systems, Brighton, CO; 303-278-6879.

2.2 EQUIPMENT

A. Furnish and install a complete, locking and control system with annunciation and control of all security subsystems utilizing touchscreen graphic controls with integrated Programmable Logic Controls. Provide all labor, equipment, materials, software, and supervision to install, calibrate, adjust, document and test the total system.

B. The locking control system shall control all electrically controlled hardware, motorized gates and other security subsystem devices. The system shall monitor and annunciate the status condition of all electrically equipped hardware, doors, gates and security subsystem control conditions, security conditions, call-in signals and other functions as described herein. The system shall interface with other security subsystems for control and annunciation as indicated.

2.3 SYSTEM CONFIGURATION:

A. The Interactive TCS Station consists of a Touchscreen monitor and a computer, which shall be connected to the Programmable Logic Controller (PLC) via a local area network. The PLC shall communicate with the TCS Station on an independent, closed network.

1. Touchscreen Control Station Consoles (TCS): The TCS shall serve as the graphic based operator interface between the corrections officer and the facility's locking controls system and the security subsystems as specified herein.
2. Programmable Logic Control System (PLC): The PLC shall provide all necessary logic transactions required to implement the functions and features of the locking control system and the security subsystem as specified herein. The PLC shall be distributive in nature and a standard product of one manufacture.

2.4 SYSTEM PERFORMANCE GUIDELINES:

A. The interaction time lag between selecting the control icon, i.e., key icon, at any given TCS and the controlled point activation, (i.e., the lock), shall be no greater than one second (1 sec).

B. The interaction time lag between a controlled point activating and any given TCS's response either by activation of an audible alarm and/or the associated icon changing state (color) shall be no greater than one second (1 sec).

C. The interaction time lag between recalling any floor plan at any given TCS shall be no greater than one second (1 sec).

2.5 MINIMUM HARDWARE REQUIREMENTS:

A. Each TCS shall consist of the following:
1. An IBM™ compatible computer with an Intel™ Xeon class E5 microprocessor chip set or equivalent. The operating speed shall be a minimum of 3.5 GHz, 16GB DDR4 SDRAM and a minimum of 8MB of Cache shall be provided.
2. The latest Operating System version from Microsoft. The Operating System shall be compatible with all software and approved during the submittal process.
3. One primary 500GB SATA 3.0Gb/s Hard Drive.
4. All necessary boards for integration to local area network, PLC's, sound system, etc., shall be provided.
5. Minimum 16X DVD-ROM Read/Write CD/DVD drive.
6. Gigabyte Network Interface Card.
7. TCS stations TCS.1A, TCS.1B, TCS.2, TCS.4A, and TCS.4B shall have an ELO "32" model 3243L Touchmonitor or equal. Unit shall provide the following features:
    a. 100 Watts or less power consumption.
    b. Operating temperature range of 41 to 95 degrees Fahrenheit.
    c. Provide custom adjustable tilt mount. Refer to A2.10.

B. Each TCS shall be provided with an optical mouse. Features shall be as follows:
1. Two customizable buttons.
2. IBM PC compatible.
3. USB or PS/2 port connection.
4. Scroll wheel.

C. Each TCS shall be provided with desk paging microphone equal to Astatic model 878HL with the following features as a minimum:
1. Frequency response of 40 to 20,000 Hz.
2. Omnidirectional microphone.
3. Push to talk momentary switch.
4. Drivers and interface boards required for control of intercom system.

D. Each TCS shall be provided with multimedia speakers equal to Sony model SRS-A212 with the following features as a minimum:
1. Response bandwidth of 90-20000 Hz.
2. 3.6 Watt RMS power output.
3. Power on/off and volume controls.
4. Active amplification.
5. Hardware as required for intercom audio and TCS voice audibles.

E. The combination of the microphone in 2.5 C and the speakers in 2.5 D above, shall provide the intercom M.I.S. as defined in section 275123.

F. Each TCS shall be provided with low profile metal cabinet to house the computer. Furnish each TCS CPU with a model CPU-1 or CPU-2 cabinet as manufactured by Computer Security Products. Furnish and install the following as a minimum:
   1. Fully vented steel doors.
   2. Welded side panels with handles.
   3. Equipment rack noted here is not required if millwork is fabricated with ventilated and lockable storage area for CPU's.

2.02 FIBER OPTIC MODULES

A. Furnish and install all fiber optic modules required for proper system operation.

B. Modules to be located in a common module rack located next to the fiber optic distribution panel in each security electronics room.

2.03 MINIMUM SOFTWARE BASE REQUIREMENTS

A. The software will be an *Off-the-She*lf package available through a distributor network. The *Off-the-Shelf* software will be programmed and tailored to the specified functions and features described herein and shown on the drawings. **Approved manufacturer of software is Wonderware or InduSoft.** All I/O server software packages shall standard in nature and be from one of the two approved software manufacturers listed below. If an I/O package (i.e. KepWare, TopServer…..) is used other than from the approved list, it shall be sent to the engineer for approval prior to being used to develop any programming. **Custom or Proprietary software code will not be approved.** The software will convey an accurate floor plan of all areas, which require display on the monitor. The software will utilize the maximum resolution and colors of the monitor to enhance and simplify the displayed control and status information. Fast orientation and ergonomics will be the goal of all graphic displays.

B. The software will provide log-on security password protection for all TCS's. There shall be a minimum of sixteen (16) levels of access, expandable. The software will provide a database for users. This database shall support a minimum of two hundred fifty six (256) users, expandable.

C. The software shall provide on-line utilities, accessed through the System Utilities function icon. These utilities shall provide the operator with the ability to edit and update required databases, system operating variables, report configuration and generation, alarm tags and point descriptions, etc. These utilities shall be protected by security levels and password requirements.

D. The software will automatically align and adjust the monitor display during the boot-up sequence of the TCS without interaction of the correction officer.

E. All software licenses shall be transferred to the Owner at completion of the project. This shall include, but not be limited to all original installation disks, software manuals, equipment manuals, etc., all project specific application software shall be transferred at the end of warranty period. The use of removable software licenses is prohibited.

F. The software license utilized shall be loaded directly onto each station. The use of a removable or "hard key" style license is not acceptable.

G. All application programming interfaces (APIS), Middleware, device drivers, dynamic-link libraries (DLL, GNU, etc. files), firmware, executable files, and all other software used as a part of the software/firmware/hardware framework shall be open source and non-proprietary. The contractor is to provide in the submittal a software architectural model detailing the HMI-PLC-DEVICE software architecture.

2.3 SPARE PARTS

A. Furnish one spare computer and monitor to match what is provided for a typical TCS station.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordination With Other Trades: The contractor shall coordinate the work of this section with that of other Divisions as required to ensure that the entire work of this project will be carried out in an orderly, complete and coordinated fashion.

B. Millwork: Completely coordinate cable and raceway access with millwork provider at each TCS location.

C. Field Wiring: The wiring that extends from the electronic control relay screw terminal strips to the locks, lights, etc. shall be class 1, 2, or 3 as defined by Article 725 of the California Electric Code. All conductors shall be 14 gauge or larger THHN or THWN, 600 volt rated, and shall be installed in raceways and equipment enclosures with other conductors, within limitations defined by Article 725 of the California Electric Code.

1. Installation: Dress wires and cables to provide a neat and orderly appearance within all enclosures, equipment racks, cabinets, and consoles by routing in snap-cover, plastic wiring duct. In locations where wiring duct is not feasible, organize by cable clamping, dressing and tie-wrapping.
2. Strain Relief: Relieve strain on all loose wire bundles using tie-wrap, supports fastened with machine screws or bolts. Do not use self-adhesive type supports.
3. Shrink Tubing: Neatly form cable ends and apply shrinkable tubing to shielded cables or where necessary to secure the insulation against fraying or raveling.
4. Edge Protection: Install edge protection materials on edges, holes, lips of ducts, or any other place where wires or cables cross sharp metallic edges.
5. Service Loops: Allow sufficient service loops where conductors leave cabinet or transition to door mounted electronics.
6. Splicing: Field wiring shall not be spliced. All wiring shall be continuous from the field device to the termination in the control panel.
7. Future Wiring: All wiring not utilized in the current configuration shall be terminated at both ends and labeled for “Future” use.

D. Ground System: Connection to grounds for Transient Voltage Surge Suppressors shall be 1 ohms or less. All grounds shall be installed as required by the CEC.

E. Ground Wire: Furnish and install a ground wire sized as required by the CEC in all conduits containing conductors carrying voltages above 30 volts rms.

F. Listing: All wiring and raceways shall be listed for the intended installation and installed in strict accordance with the California Electric Code as required by the conditions of where it is stalled. This includes but is not limited to ratings for risers, plenum, or wet installations.

3.2 PROGRAMMING

A. Library: The TCS programming shall utilize a library of reusable, programmed modules. Programming a function will consist of submitting a point list to the appropriate program module and acting on the results.

B. Testing: All programming will be completely tested and debugged in the factory before being sent to the site for installation. Each response for each point shall be tested by an actual device or by software manipulation.

C. Personnel: All programmers developing software for the TCS systems shall be experienced programmers completely trained in the operation of the computers involved. The software shall be tested by competent programmers other than the developers.

3.3 FABRICATION

A. All cables between PLC and TCS shall be provided with quick disconnect connectors for ease of trouble-shooting and service.

B. All field wiring shall be landed on appropriately labeled terminal strips.

C. All wiring shall be cabled or neatly bundled and secured to the housing with wire ties and internal wire ducts.

3.4 TRAINING

A. The ESC shall provide without additional cost to the owner representatives specially trained in the operation of the Touchscreen systems provided. The representatives shall train the Owner’s personnel in operation, repair, and upkeep of the PLC and custom relay cabinets.

B. The ESC shall be responsible for notifying the architect five (5) weeks prior to substantial completion of the total security system that training is scheduled. The ESC will coordinate the number to be trained with the owner’s representative. The Touchscreen training will be provided in conjunction with the PLC training as these systems are integrated with each other.

C. The length of training shall be at least four hours long and be presented to all shifts.

D. Course Structure
1. The ESC shall prepare and present to the Architect a detailed course outline that specifies each major training module to be covered. The training program on the security equipment shall include the sequences and instructions for proper use and maintenance of all hardware, locking devices, control and monitoring systems and panels. The material content shall be in simple layman’s terminology, describe and demonstrate all step-by-step physical operations necessary for proper operation and necessary equipment adjustments. At the time of training, each trainer shall present to the trainees detailed

outlines of each training module to be covered and the specific skills and knowledge which the trainee is expected to master within each training module.

2. At a minimum the training program shall be subdivided into the following training modules:
   a. Troubleshooting, General Maintenance, Equipment Adjustments, Repair and Replacement of Security System Components.
   b. Operator Controls.
   c. Descriptive modules organized by specification section.
   d. Review of panel as built plans and submittals.
   e. Review of Operation and Maintenance Manuals.
   f. Review of all contact telephone numbers.
   g. Review of all warranties.

E. The ESC shall record each training module. The recording does not have to include individual student practice. The ESC in preparing the recording shall structure it for easy reference by the facility's training officer for future use. Furnish to the owner DVD's or tape as required by the owner.

F. Training Certification
   1. Each facility employee shall receive at the conclusion of the security systems training program a certificate certifying his attendance of the total session or portion thereof.
   2. ESC shall maintain attendance records of each class.

G. In addition to the training requirements listed above the ESC shall include all associated cost to provide additional onsite owner training following substantial completion. The additional training shall occur at the three (3) months periods and shall cover topics as referenced in paragraph "D" above. Coordinate this additional training with the owner.

3.5 FIELD QUALITY CONTROL

A. All functions specified shall be individually activated and the result documented. .

B. All functions shall be demonstrated for the Owner and Consultant's representative.

TCS VERIFICATION AND CHECK-OUT FORM

✓ = OK

Job #
Job Name:
Panel #

FIELD TEST CODE:		**REPAIR CODE:**	
A - No status change	M - Poor audio	1-SSI	Software Test By:_____ Date_____
B - Won't show secure	N - No audio	2-ELECTRICIAN	
C - No power to door	O - Out of focus	3-IRONWORKER	Hardware Test By:_____ Date_____
D - Door won't open	P - No picture	4-CARPENTER	
E - Door won't close	Q - Call button sticks	5-OWNER/REP	System Test By:_____ Date_____
F - Door needs alignment	R - Reversed	6 -ENG	
G - Wrong door opens	S - Software problem	7 -	Design Engineering By:_____ Date_____
H - Adjust DPS	T - Not installed	8 -	
I - Adjust roller bolt	U -	9 -	Wiring By:_____ Date_____
J - File strike plate	V -	10 -	
K - Adjust lock	W -	11 -	Field Test By:_____ Date_____
L - No latch back	X -	12 -	

							ON-SITE				
ICON ID#	**ICON TYPE**	**C/U CAM. NO.**	**DOOR INTLK WITH**	**CELL GRP. REL.**	**SOFT-WARE TEST**	**HARD-WARE TEST**	**FIELD TEST CODE**	**REPAIR CODE**	**RE-CHECK "X"**	**FIELD CHECK OUT NOTES**	**PROBLEM RESOLVED (BY/DATE)**

3.6 SOFTWARE

A. For each TCS, furnish to the owner uniquely identified:
   1. One (1) copy of the programming and source code of the application software on a CD or DVD. This copy shall have all programmer comments, variable names, and mnemonics included.
   2. Complete and accurate set of programming work sheets filled out with the final configuration for each system.
   3. One (1) back-up CD or DVD with programmer's notes and source code. Each disk will be labeled with the project name, programs, programmer, and revision date.

B. Furnish a single Adobe Acrobat PDF file detailing all passwords for each TCS. This file shall also identify the following by system and panel:
   1. The file name of each program required for restoration of each failed TCS.
   2. The passwords required for each TCS as well as required programs.
   3. The name of the programmers for each custom program.
   4. The date of the last program change.

C. Furnish documents listed in 3.4 A-B at project completion. Furnish a new set with all revisions after the completion of the three month reprogram specified in 280500, 1.8-C.

END OF SECTION 284600

SECTION 28 4600.1 - SECURITY ELECTRONICS CONTROL MATRIX

The Control Matrix is a tool to aid in the programming of the Locking Control System for the Monterey Juvenile Hall. Each device that is a part of the locking control system is listed in the first column below.

The Interlock Groups in the second column define the sally ports in the facility. If doors are interlocked in a group, only one door can be open in the group at a time without the TCS operator completing extra steps.

The third column shows the Emergency Release groups. There are currently 9 emergency release groups. They are:

Standard Housing 1A or **SHA**
Standard Housing 1B or **SHB**
High Security Housing 2 or **HSH**
New Dorm Housing or **NDH** ***ADD ALTERNATE**
Administration or **ADM**
Kitchen/Laundry/Warehouse or **KLW**
Gym & School or **GS**
Remodeled Dorm or **RD**
Overall Site or **SP**

The activation of an emergency release group will open all of the doors associated with the group and hold the locks open. Emergency Release can only be activated from Central Control in room 102 of the Administration building.

The Camera Call-Up column defines which camera will appear on the station's video spot monitor when an intercom or duress is activated.

The next seven columns are used to define Task Groups. Task Groups are a logical group of devices that can be transferred from one Touchscreen Control Station (TCS) to another. There are five control stations at Monterey Juvenile Hall. The primary control stations are TCS.4A and TCS.4B, located in Central Control in room 102. TCS.4A & TCS.4B utilize task groups to divide up and control the facility and are interchangeable. Neither station would be able to control the same task group at the same time. The nine task groups would be transferred between these two stations. The Task Groups at the Monterey juvenile facility are:

Standard Housing 1A or **SHA**
Standard Housing 1B or **SHB**
High Security Housing 2 or **HSH**
New Dorm Housing or **NDH** ***ADD ALTERNATE**
Administration or **ADM**
Kitchen/Laundry/Warehouse or **KLW**
Gym & School or **GS**
Remodeled Dorm or **RD**
Overall Site or **SP**

The remaining stations are located in Standard Housing 1A, Standard Housing 1B, and High Security Housing 2. TCS.1A is located at the Officer Station 106 in 1A. This station receives intercom calls from the cells only. TCS.1B is located at the Officer Station 106 in 1B. This station receives intercom calls from the cells only. TCS.2 is located at the Officer Station 109 in 2. These stations receives intercom calls from the cells only. These stations can be enabled and disabled from Central Control.

The Card Access Column (**CARD**) distinguishes devices that are a part of the card access system. Some devices are integrated into both the card access and locking control system.

The remaining column is for additional notes that might distinguish a device from a similar device. The notes are as follows:

CONTROL MATRIX KEYED NOTES

1 Task Group (or Station) has primary control and monitoring.
2 Task Group (or Station) has monitoring only.
3 A trouble alarm will register on the TCS that is assigned this task group.
4 When a local Duress is activated, the local TCS is disabled. Central Control station must re-activate the local TCS.
5 When the call station is pressed, it will activate the call icon and illuminate the corridor dome light. Call icon on the TCS will be flashing yellow and dome light will flash.
6 Activation of this device shall be recorded on the Event Recording Computer.
7 This device is controlled from the card access system and the locking control system.
8 This door is controlled from by access control and is not integrated with the locking control system.
9 Device is added under the Add Alternate.
10 HIGH SECURITY RISK pop up window to appear when this door is signaled to be open.
11 DOOR OPEN TOO LONG pop up window will appear when this door is opened to long.
12 DOOR KEYED OPEN alarm to register when this door is opened by means other than the TCS station.

Device	Interlk Group	Emerg Release	Camera Call-Up	TCS 1A	TCS 1B	TCS 2	SHA	SHB	HSH	NDH	ADM	KLW	GS	RD	SP	Card	Note #
Site Plan																	
Intercom Stations																	
308.1			ST01												1		6, 9
301.1			ST33												1		6
302.1			ST34												1		6
303.1			ST35												1		6
202.1			ST34												1		6
202.2															1		6
210.1			ST35												1		6
210.2			ST36												1		6
218.1			ST32												1		6, 9
218.2			ST31												1		6, 9
Individual Gate Control																	
308															1	1,7	6, 9
307															1		6, 9
301	S1														1		6
303	S2														1		6
302	S1, S2														1		6
210	S2	SP													1		6,10, 11,12
216		SP													1		6
213		SP													1		6

Device	Interlk Group	Emerg Release	Camera Call-Up	TCS 1A	TCS 1B	TCS 2	S H A	S H B	H S H	N D H	A D M	K L W	G S	R D	SP	Card	Note #
212		SP													1		6
211															2		6
214		SP													1		6
202	S1, S2	SP													1		6,11, 12
218		SP													1		6, 9, 11,12
219		SP													1		6, 9
Photoelectric Beams																	
308.1			ST01												2		6, 9
308.2			ST01												2		6, 9
307.1			ST31												2		6, 9
307.2			ST31												2		6, 9
301.1			ST33												2		6
301.2			ST33												2		6
302.1			ST34												2		6
302.2			ST34												2		6
303.1			ST35												2		6
303.2			ST35												2		6
Loop Detectors																	
308.1															2		6, 9
308.2															2		6, 9
307.1															2		6, 9
307.2															2		6, 9
301.1															2		6
301.2															2		6
303.1															2		6
303.2															2		6
302.1															2		6
302.2															2		6
Push Buttons																	
216.1															2		6
213.1															2		6
212.1															2		6
214.1															2		6
219.1															2		6, 9
Watch Tour																	
ST01															2	7	6

Device	Interlk Group	Emerg Release	Camera Call-Up	TCS 1A	TCS 1B	TCS 2	S H A	S H B	H S H	N D H	A D M	K L W	G S	R D	SP	Card	Note #
ST02															2	7	6
ST03															2	7	6
ST04															2	7	6
ST05															2	7	6
ST06															2	7	6
ST07															2	7	6
ST08															2	7	6
ST09															2	7	6
ST10															2	7	6
ST11															2	7	6
ST12															2	7	6
ST13															2	7	6
ST14															2	7	6
ST15															2	7	6
ST16															2	7	6
Building 1A																	
Individual Intercom Stations																	
Cell 113-128			A08	1													6
Cell 133-140			A04	1													6
A100.1			ST29				1										6
A100.2			A07				1										6
A106			A06				1										6
Watch Tour																	
RDR A01							2									7	6
A02							2									7	6
A03							2									7	6
A04							2									7	6
RDR A05							2									7	6
A06							2									7	6
A07							2									7	6
Duress Station																	
A01			A06	4			2										6
Individual Door Control																	
Cell 113-128		SHA		2			2										6
111B		SHA		2			2										6, 11,12
Cell 133-140		SHA		2			2										6

Device	Interlk Group	Emerg Release	Camera Call-Up	TCS 1A	TCS 1B	TCS 2	SHA	SHB	HSH	NDH	ADM	KLW	GS	RD	SP	Card	Note #
131B		SHA		2			2										6, 11,12
101B	A1	SHA		2			2										6
141B	A1	SHA		2			2										6, 11,12
141A	A1	SHA		2			2										6, 11,12
100		SHA		2			1										6, 10, 11,12
Dayroom 111 Auxiliary Controls																	
Youth Phones							1										6
Dayroom 131 Auxiliary Controls																	
Youth Phones							1										6
Monitored Doors																	
130							2										6
SEC130 System Alarms																	
PLC Communication Failure							2,3										6
UPS Active/Power Failure							2,3										6
UPS Low Battery							2,3										6
UPS Low Voltage							2,3										6
UPS Inverter Power							2,3										6
UPS Trouble							2,3										6
120 VAC TVSS Failure							2,3										6
TCS Duress Alarm							2,3										6
Building 1B																	
Intercom Stations																	
B100.1			ST21					1									6
B100.2			B03					1									6
B106			B04					1									6
Cell 113-128			B02		1												6
Cell 133-140			B05		1												6
Watch Tour																	
RDR B01								2								7	6

Device	Interlk Group	Emerg Release	Camera Call-Up	TCS 1A	TCS 1B	TCS 2	SHA	SHB	HSH	NDH	ADM	KLW	GS	RD	SP	Card	Note #
B02								2								7	6
B03								2								7	6
RDR B04								2								7	6
B05								2								7	6
B06								2								7	6
B07								2								7	6
Duress Button																	
B106			B04		4			2									6
Individual Door Control																	
100		SHB			2			1									6, 10, 11,12
101B	B1	SHB			2			2									6
141A	B1	SHB			2			2									6, 11,12
141B	B1	SHB			2			2									6, 11,12
131B		SHB			2			2									6, 11,12
111B		SHB			2			2									6, 11,12
Cells 113-128		SHB			2			2									6
Cells 133-140		SHB			2			2									6
Dayroom 111 Auxiliary Controls																	
Youth Phones								1									6
Dayroom 131 Auxiliary Controls																	
Youth Phones								1									6
Monitored Doors																	
130								2									6
SEC 130 System Alarms																	
PLC Communication Failure								2,3									6
UPS Active/Power Failure								2,3									6
UPS Low Battery								2,3									6
UPS Low Voltage								2,3									6

Device	Interlk Group	Emerg Release	Camera Call-Up	TCS 1A	TCS 1B	TCS 2	S H A	S H B	H S H	N D H	A D M	K L W	G S	R D	SP	Card	Note #
UPS Inverter Power								2,3									6
UPS Trouble								2,3									6
120 VAC TVSS Failure								2,3									6
TCS Duress Alarm								2,3									6
Building 2																	
Individual Intercom Stations																	
2100.1			ST14						1								6
2100.2			207						1								6
206			210						1								6
Cell 115-130			214			1											6
Cell 135-142			203			1											6
Watch Tour																	
RDR 201									2							7	6
202									2							7	6
203									2							7	6
RDR 204									2							7	6
205									2							7	6
206									2							7	6
207									2							7	6
Duress Button																	
201			210			4			2								6
Individual Door Control																	
100		HSH				2			1								6, 10, 11
110B		HSH				2			2								6, 11,12
143A	HS1	HSH				2			2								6, 11,12
143B	HS1	HSH				2			2								6, 11,12
133B		HSH				2			2								6, 11,12
112B		HSH				2			2								6, 11,12
113B		HSH				2			2								6, 11,12
108B	HS1	HSH				2			2								6

Device	Interlk Group	Emerg Release	Camera Call-Up	TCS 1A	TCS 1B	TCS 2	S H A	S H B	H S H	N D H	A D M	K L W	G S	R D	SP	Card	Note #
Cells 115-130		HSH				2			2								6
Cells 135-142		HSH				2			2								6
Dayroom 113 Auxiliary Controls																	
Youth Phones									1								6
Dayroom 133 Auxiliary Controls																	
Youth Phones									1								6
Monitored Doors																	
104									2								6
132									2								6
SEC 132 System Alarms																	
PLC Communication Failure									2,3								6
UPS Active/Power Failure									2,3								6
UPS Low Battery									2,3								6
UPS Low Voltage									2,3								6
UPS Inverter Power									2,3								6
UPS Trouble									2,3								6
120 VAC TVSS Failure									2,3								6
TCS Duress Alarm									2,3								6
Building 3 – ADD ALTERNATE																	
Individual Intercom Stations																	
3100.1			ST38							1							6, 9
3100.2			305							1							6, 9
301			301							1							6, 9
302			302							1							6, 9
303			310							1							6, 9
306			304							1							6, 9
Watch Tour																	
RDR 301										2						7	6, 9
302										2						7	6, 9
303										2						7	6, 9
RDR 304										2						7	6, 9
305										2						7	6, 9

Device	Interlk Group	Emerg Release	Camera Call-Up	TCS 1A	TCS 1B	TCS 2	SHA	SHB	HSH	NDH	ADM	KLW	GS	RD	SP	Card	Note #
306										2						7	6, 9
307										2						7	6, 9
Duress Buttons																	
301			308							2							6, 9
Individual Door Control																	
100		NDH								1							6, 9, 10,11, 12
111B		NDH								2							6, 9, 11,12
101B	D1	NDH								2							6, 9
122		NDH								2							6, 9, 11,12
123A	D1	NDH								2							6, 9, 11,12
123B	D1	NDH								2							6, 9, 11,12
Dayroom 111 Auxiliary Controls																	
Youth Phones										1							6, 9
Dayroom 119 Auxiliary Controls																	
Youth Phones										1							6, 9
Monitored Doors																	
118										2							6, 9
SEC C118 SYSTEM ALARMS																	
UPS Active/Power Failure										2, 3							6, 9
UPS Low Battery										2, 3							6, 9
UPS Low Voltage										2, 3							6, 9
UPS Inverter Power										2, 3							6, 9
UPS Trouble										2, 3							6, 9
120 VAC TVSS Failure										2, 3							6, 9

Device	Interlk Group	Emerg Release	Camera Call-Up	TCS 1A	TCS 1B	TCS 2	S H A	S H B	H S H	N D H	A D M	K L W	G S	R D	SP	Card	Note #
PLC Communication Failure										2, 3							6, 9
Building 4																	
Intercom Stations																	
110.1			412								1						6
110.2			401								1						6
119B.1			ST04								1						6
119B.2			418								1						6
119A.1			418								1						6
119A.2			412								1						6
108A.1			404								1						6
108A.2			407								1						6
104A.1											1						6
104A.2			403								1						6
104B.1			415								1						6
104B.2											1						6
161A.1											1						6
161A.2											1						6
102.1											1						6
102.2											1						6
163A.1											1						6
163A.2											1						6
161B.1											1						6
161B.2											1						6
108B.1			408								1						6
108B.2			406								1						6
100A.1											1						6
152.1			ST11								1						6
139.1											1						6
Call Button																	
138 Non-Contact Visiting											2						6
141 Non-Contact Visiting											2						6
Dome Lamp																	
138 Non-Contact Visiting											2						6
Reset Button																	

Device	Interlk Group	Emerg Release	Camera Call-Up	TCS 1A	TCS 1B	TCS 2	SHA	SHB	HSH	NDH	ADM	KLW	GS	RD	SP	Card	Note #
138 Non-Contact Visiting											2						6
Duress Button																	
401 Nurse Workroom											2						6
402 Med Exam			410								2						6
403 Med Screening			410								2						6
404 Processing			411								2						6
405 Contact Visiting			405								2						6
406 Meeting											2						6
Individual Door Control																	
161A	A1	ADM									1						6, 11,12
102											1						6, 11,12
163A	A1	ADM									1						6, 11,12
161B	A1	ADM									1						6, 11,12
108A	A2	ADM	404								1						6, 11,12
108B	A2	ADM									1						6, 11,12
141		ADM									1						6, 11
139A	A3	ADM									1						6, 11
139B	A3	ADM									1						6, 11
119A	A4	ADM	418								1						6, 11
119B	A4	ADM									1						6, 11
104A	A5	ADM									1						6, 11,12
104B	A5	ADM									1						6, 11,12
152		ADM									1					7	6
100A		ADM									1					7	6
172B		ADM									2					7	6
170		ADM									2					7	6
148		ADM									2					7	6
165B		ADM									2					7	6
100B		ADM									2					7	6
163B		ADM									2					7	6
131		ADM									2					7	6
132		ADM									2					7	6

Device	Interlk Group	Emerg Release	Camera Call-Up	TCS 1A	TCS 1B	TCS 2	SHA	SHB	HSH	NDH	ADM	KLW	GS	RD	SP	Card	Note #
126		ADM									2					7	6
Monitored Doors																	
155											2						6
162											2						6
107											2						6
SEC 162 SYSTEM ALARMS																	
UPS Active/Power Failure											2,3						6
UPS Low Battery											2,3						6
UPS Low Voltage											2,3						6
UPS Inverter Power											2,3						6
UPS Trouble											2,3						6
120 VAC TVSS Failure											2,3						6
TCS Duress Alarm											2,3						6
PLC Communication Failure											2,3						6
Building 5																	
Individual Intercom Stations																	
127A.1			507									1					6
127A.2												1					6
127B.1												1					6
127B.2			ST07									1					6
Individual Control Doors																	
127A	W1	KLW										1					6, 10, 11,12
127B	W1	KLW										1					6, 10, 11,12
Monitored Doors																	
108												2					6
116												2					6
SEC 116 SYSTEM ALARMS																	
UPS Active/Power Failure												2,3					6
UPS Low Battery												2,3					6

Device	Interlk Group	Emerg Release	Camera Call-Up	TCS 1A	TCS 1B	TCS 2	SHA	SHB	HSH	NDH	ADM	KLW	GS	RD	SP	Card	Note #
UPS Low Voltage												2,3					6
UPS Inverter Power												2,3					6
UPS Trouble												2,3					6
120 VAC TVSS Failure												2,3					6
PLC Communication Failure												2,3					6
Building 6																	
Individual Intercom Stations																	
601 Staff Station													1				6
Duress Buttons																	
601 Classroom			601										2				6
602 Classroom			605										2				6
603 Gym			610										2				6
604 Gym			607										2				6
605 Classroom			614										2				6
606 Classroom			613										2				6
607 Staff Station			ST23										2				6
Watch Tour																	
RDR 601													2			7	6
602													2			7	6
603													2			7	6
604													2			7	6
605													2			7	6
606													2			7	6
Monitored Doors																	
113													2				6
121													2				6
102B													2				6
SEC 121 SYSTEM ALARMS																	
UPS Active/Power Failure													2, 3				6
UPS Low Battery													2, 3				6
UPS Low Voltage													2, 3				6

Device	Interlk Group	Emerg Release	Camera Call-Up	TCS 1A	TCS 1B	TCS 2	SHA	SHB	HSH	NDH	ADM	KLW	GS	RD	SP	Card	Note #
UPS Inverter Power													2, 3				6
UPS Trouble													2, 3				6
120 VAC TVSS Failure													2, 3				6
PLC Communication Failure													2, 3				6
Building 7																	
Individual Intercom Stations																	
407.1														1			6
428.1														1			6
391.1														1			6
405.1														1			6
Controlled Doors																	
101A	R1	RD												1			6, 10, 11,12
101B	R1	RD												1			6, 10, 11,12
107A	R1, R3	RD												1			6,
112A	R1, R2	RD												1			6
114	R2	RD												2			6, 11,12
109	R3	RD												2			6, 11,12

EMERGENCY RELEASE GOUPS

GROUP	OPENS DOORS
SHA	CELLS 113-128, CELLS 133-140, 111B, 131B, 101B, 141B, 141A, 100
SHB	CELLS 113-128, CELLS 133-140, 111B, 131B, 101B, 141B, 141A, 100
HSH	CELLS 115-130, CELLS 135-142, 100, 110B, 143A, 143B, 133B, 112B, 113B, 108B
NDH	100, 111B, 101B, 122, 123A, 123B
ADM	161A, 163A, 161B, 108A, 108B, 141, 139A, 139B, 119A, 119B, 104A, 104B, 152, 172B, 170, 148, 165B, 100B, 163B, 131, 132, 126, 100A
KLW	127A, 127B

GS	
RD	101A, 101B, 107A, 112A, 109, 114
SP	202, 210, 212, 213, 214, 216, 218, 219

END OF SECTION 284600.1

SECTION 284600.2 - EVENT RECORDING SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. Scope of work: Furnish and install all components for an Event Recording System integrated with the security systems as indicated on the plans and described herein.

B. The ESC as defined in Section 280500 Common Work Results for Electronic Safety and Security shall be responsible for providing and coordinating this system.

1.02 SYSTEM DESCRIPTION

A. Event Recording Computer: The Event Recording Computer (ERC) shall be a computer terminal with the appropriate cards and programming incorporated into it to form an integrated unit to serve as an operator interface for the PLC system.

B. Basic Operation: All critical events monitored and controlled by the PLC will be recorded with Operator Identification, event, time and date on the ERC‘s hard drive.

C. Graphic Plans: The ERC shall provide graphic representations of each area to aid in defining points recorded. Each graphic is to be a 1/8” scaled depiction of each area. Graphics are to be sized for proper operation of control icons and useful building representations.

1. Key Plan: A facility key plan will be available on all graphic screens. Touching an area of the key plan will call up a graphic of the area providing control icons and more detailed building information. Icons as described below will be located on the plan to graphically locate where in the facility the controlled item is installed. The area plans are the second level of graphic zoom.
2. Detail Window: Detail plan windows shall be provided for any section of the graphic plan where there is a high concentration of controls making it impossible to properly indicate all icons. This shall be the second and last level of graphical zoom.

1.03 REPORT FUNCTIONS

A. System Historical Journal:

1. The system shall maintain a history file on the hard disk. The history data shall be organized into a logically circular file such that the most recent 500,000 (minimum) transactions are accessible directly from the hard disk without having to resort to archival media. Points to be recorded are as follows:
   a. Staff duress activation.
   b. Staff duress reset.
   c. Unlock commands from Touchscreen Control Station (TCS) units.
   d. Intercom call placed.
   e. Intercom call answered by TCS.
   f. Intercom call reset.
   g. Call button placed.

h. Call button reset.
i. TCS controlled doors opened by means other than the TCS.
j. Monitored door activation.
k. Vehicle loop activation.
l. Watch tour start and finish.
m. Individual watch tour station activation.
n. 120 VAC TVSS failure.
o. Loss of power.
p. Interlock override activation.
q. Alarm reset.
r. Signal Silence.
s. TCS operator log in and log out.

2. All information shall be stored in an SQL database.
3. Each history entry in the journal shall be marked with the date and time of its occurrence, the name of the operator logged on (if applicable), and the terminal from which the event was initiated (if applicable).
4. The system shall provide a method by which incremental sections of the historical journal may be backed up to magnetic tape media, compact disk, or flash memory for storage and later recall. The system journal archive method shall be sufficient to assure that no events are lost in the transfer from hard disk to the archive media.
5. In addition, the journal archive method shall preserve the contents of all data in the on-line portion of the historical journal until the disk space occupied by data must be reclaimed for use in an oldest-first order.
6. Data shall be stored on the ERC hard drive and be available for a minimum of 90 days. At the end of the 90th day, the day 1 data shall automatically be deleted from the data base. Each day following this point, the oldest days data shall be automatically deleted from the hard drive as the new day's data is preserved.

B. Operator Comments:

1. The system shall allow operator comments to be entered from the TCS for any duress alarm condition.
   a. When the alarm is active, allow the operator to select an icon and enter up to 1000 characters of information for the event.
   b. Store the operator comment tagged to the event for as long as the event is stored.
   c. When the tagged event is deleted or overwritten, delete the comment.
2. Provide memory for 10,000 operator comments.
3. Provide the operator the ability to search operator comments for a particular word or character string.

C. Historical Reports:

1. The system shall be capable of producing the following reports of historical events over a specified time range, both individually and in any combination from the historical journals.
2. Report of alarms or group of alarms. As a minimum, provide reporting of the following alarms:
   a. Staff Duress Activation
   b. Staff Duress Clear
   c. TVSS Fault
   d. Power/UPS Fault

e. PLC Fault

3. Report of event activation for a selected event or group of events. As a minimum, provide reporting of the following events:
   a. Watch Tour Start
   b. Watch Tour Finish
   c. Watch Tour Station Activation
   d. Emergency Release Activation
   e. Interlock Override
   f. Group Release
   g. Controlled Door / Gate Lock Activation
   h. Controlled Door Gate Slider Operation
4. Report of operator comments.
5. Each TCS activation shall be recorded with time, date, event, and operator identification number. Non TCS events shall be recorded with time, date, and event.
6. Report of manual operator overrides actions (acknowledge, reset, manual door unlocks, etc.).
7. Report of automatic system actions (automatic door unlocks).
8. The system shall be capable of generating these reports in a format that is user defined. Search and sort capacity shall include sorts by the field parameters defined by the user, sorts alphabetically and sorts numerically.
9. The ESC shall set create a list of pre-defined reports. The pre-defined report shall only require that the date and time be determined before generating the report. At a minimum provide the following pre-defined report options:
   a. Watch Tour System Activities
   b. Emergency Release Activation
   c. Interlock Override Activations
   d. Door alarms
   e. Duress Alarms
   f. Trouble Alarms

D. Preventive Maintenance Reports

1. The system shall be capable of keeping running totals and summations.
2. The system shall be capable of producing reports identifying the number of lock activations by device to identify locks requiring maintenance.

1.04 NETWORKING

A. The Event Recording System shall be part of the Security Systems local area network to include the UPS, TCS, and PLC systems. All events from these systems will be recorded to the ERC computer. The ERC computer will not be accessible to the owner's LAN.

B. The Security and PLC systems will not be accessible from the owner's LAN over the ERC computer network connection.

1.05 SUBMITTALS

A. Provide basic submittals as required by Section 280500 Common Work Results for Electronic Safety and Security and by the General Contract requirements.

B. In addition, submit color prints of all graphic screens for approval.

C. Also submit a list of all reportable alarm points.

D. Submit a flow chart of all proposed screens.

1.06 SYSTEMS INTEGRATION

A. Integrated Systems: The Event Recording System shall be integrated with the other systems including, but not limited to:

1. The TCS.
2. The Door Locking Control system.
3. PLC system.
4. Intercom System.
5. IP video system
6. UPS system.
7. Card access

B. The ERC CPU shall not be used as an “application server” to the locking control/PLC control system. The ERC is for data storage and shall function as a database server.

1.07 SOFTWARE BACKUP

A. This unit shall provide backup and storage for all custom programs in a program folder entitled BACKUP.

B. Backup program folder shall contain a copy of the backup software for each TCS so that the programming can be recreated if the backup CD is lost or damaged.

PART 2 - PRODUCTS

2.01 MINIMUM HARDWARE REQUIREMENTS:

A. The ERC machine shall be equal to the Dell PowerEdge T430 Tower Server which consists of the following:
1. An IBM™ compatible computer with an Intel™ Xeon class E5 microprocessor chip set or equivalent. The operating speed shall be a minimum of 2.4 GHz, 16GB DDR4 SDRAM and a minimum of 20MB of Cache shall be provided.
2. Windows Server 2012R2 Standard Edition.
3. Two primary 2GB SATA 6.0 Gb/s Hard Drive.
4. All necessary boards for integration to local area network, PLC's, sound system, etc., shall be provided.
5. Minimum 16X DVD-ROM Read/Write CD/DVD drive.
6. Gigabyte Network Interface Card.
7. A nineteen-inch (19”) LCD flat screen monitor equal to NEC AccuSync ASLCD92V.
8. All necessary boards for integration to local area network, PLC's shall be provided.

2.02 MINIMUM SOFTWARE BASE REQUIREMENTS

A. The software will be a*n Off-the-She*lf package available through a distributor network. The Off-the-Self software will be programmed and tailored to the specified functions and features described herein and shown on the drawings. The database shall be programmed in SQL.

B. The software will provide common database functions, templates, and forms.

C. All software licenses shall be transferred to the Owner at completion of the project. This shall include, but not be limited to all original installation disks, software manuals, equipment manuals, etc., all project specific application software shall be transferred at the end of warranty period.

2.03 SYSTEM PRINTER:

A. Acceptable Manufacturers:

1. Hewlett Packard
2. Epson
3. Cannon

B. Connection: Furnish and install a system printer. The system printer shall be connected to the server ERC for report printing. All printing shall be by operator request. The system shall not automatically print events.

C. Type: Furnish and install a HP 200 LaserJet pro color printer (or equal).

1. Print up to 14 pages per minute monochrome.
2. Print up to 14 pages per minute color.
3. On-screen ink level indicator and print cancel button.
4. Recommended monthly page volume of 1,500 pages.

D. Up to 3600 optimized dpi.

E. Unit shall not print alarms as they occur.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Coordination with Other Trades: The contractor shall coordinate the work of this section with that of other divisions as required to ensure that the entire work of this project will be carried out in an orderly, complete and coordinated fashion.

B. Software: All source code, programming keys, and printouts of the operating program shall be furnished to the Owner at the end of the project.

C. The ERC CPU shall reside in a lockable ventilated cabinet as manufactured by CSP, model number CPU1, CPU2 or equal. Unit shall have a ventilation fan. ESC shall verify that all racks are sized for the electronics scheduled for each area. Verify that appropriate space is provided in cabinets for ERC and the required accessories.

D. UPS: Furnish and install a UPS to power all ERC components. This shall be in addition to providing emergency power.

E. Listing: All wiring and raceways shall be listed for the intended installation and installed in strict accordance with the California Electric Code as required by the conditions of where it is installed. This includes but is not limited to ratings for riser, plenum, or wet installations.

3.02 FIELD QUALITY CONTROL

A. All functions specified above shall be individually activated and the result documented. Test reports shall be printed lists. Note each function as "pass" or "fail". The completed test reports shall be copied and submitted to the engineer prior to final inspection.

B. All functions shall be demonstrated for the Owner's, Architect's, and Consultant's representative.

EVENT RECORDING VERIFICATION AND CHECK-OUT FORM

√ = OK

Job #
Job Name:
Panel #

FIELD TEST CODE:		**REPAIR CODE:**	
A - No status change	M -	1-SSI	Software Test By:_____ Date_____
B- No power to ERC	N -	2-ELECTRICIAN	
C -Software problem	O -	3-IRONWORKER	Hardware Test By:_____ Date_____
D -Not installed	P -	4-CARPENTER	
E -	Q -	5-OWNER/REP	System Test By:_____ Date_____
F -	R -	6 -ENG	
G -	S -	7 -	Design Engineering By:_____ Date_____
H -	T -	8 -	
I -	U -	9 -	Wiring By:_____ Date_____
J -	V -	10 -	
K -	W -	11 -	Field Test By:_____ Date_____
L -	X -	12 -	

							ON-SITE				
ICON ID#	**ICON TYPE**				**SOFT-WARE TEST**	**ERC TEST**	**FIELD TEST CODE**	**REPAIR CODE**	**RE-CHECK "X"**	**FIELD CHECK OUT NOTES**	**PROBLEM RESOLVED (BY/DATE)**

3.03 SOFTWARE:

A. For the ERC, furnish to the owner uniquely identified:

1. One (1) separate back-up CD or Disc for the ERC program. Label the disk with the project name, programs, programmer, and revision date.

B. Furnish a single Microsoft Word file detailing all passwords for each system. This file shall also identify the following by system and panel:

1. The file name of each program required for restoration of each failed system.
2. The passwords required for each system and software.
3. The name of the programmers for each custom software program.
4. The date of the last program change.

C. Furnish a digital copy of the facility's Operation and Maintenance Manual in PDF format on the ERC. Refer to Specification section 280500.

D. Furnish a digital copy of the As-Built documents in PDF format on the ERC. Refer to Specification section 280500.

E. Furnish digital copies of the facility training videos in a Windows Media file format (.wmv or equal) on the ERC. Files shall be easily viewable on the ERC's media player for training staff. Refer to Specification section 280500.

3.04 SPARE PARTS:

A. Spare parts shall be packaged in protective packing material. Box spare parts for easy storage and clearly identify the contents of each box on all four sides of each container.

B. Furnish the following:

1. 25 Blank Read Write CD’s
2. One (1) ream (500 sheets) of 8-1/2" x 11" printer paper.

END OF SECTION 284600.2

SECTION 28 4619 - PROGRAMMABLE LOGIC CONTROLLER (PLC)

PART 1 - GENERAL

1.01 SUMMARY

A. Scope of work: Furnish and install all components for a complete and integrated Programmable Logic Controller (PLC) integrated with the security systems as indicated on the plans and described herein.

B. The ESC as defined in Section 280500 Common Work Results for Electronic Safety and Security shall be responsible for providing and coordinating this system.

C. Provide new Touchscreen Control Stations (TCS) and Event Recording Computer (ERC) stations as indicated on the plans. These stations shall function as the human-machine interface for the PLC system. Refer to Specification sections 284600 and 284600.2 for additional information.

D. Integrate all new PLC's, TCS, ERC, and IP Video system into a single control system enabling the staff to control and monitor all locations.

E. Provide a separate and dedicated fiber optic network for PLC communication.

1.02 SYSTEM DESCRIPTION

A. PLC: The PLC network shall control all of the logic functions of the operator interface stations for control and annunciation of locking control and security systems.

B. PLC CPU: The PLC CPU shall provide the necessary logic and timing functions, memory, software variables, and communication capabilities required to meet the functions described in the specifications. Each PLC location shall be provided with a CPU to allow independent degraded operations in the event of loss of network communications.

C. Master Clock: Furnish and install programming to automatically update the PLC clock for daylight savings time across all PLC's, TCS, ERC, and maintenance computers. The current time shall be transmitted to all PLC CPU's in the system. All system clocks shall be updated within 2 seconds of a change being entered at the main PLC master clock.

D. The PLC system shall be industrial general purpose in nature, not custom designed and built for this isolated application. The PLC shall be generally non-location specific in its construction. The controller shall be operationally customized and made location specific by installing the applicable software, and making the I/O interface board's system specific. All components shall be manufacturer's standard modules.

E. The PLC shall accomplish emergency release and group releases by staggering all unlock commands to minimize surges. Up to three motorized locks may be grouped together and released simultaneously. Solenoid locks shall be released individually.

F. In a single emergency release grouping, all doors shall unlock within sixty (60) seconds of the command being initiated.

G. Furnish and install a complete PLC in each PLC rack noted on the plans.

H. Removable Media: Each PLC CPU shall have a slot for a removable memory card, which allows the PLC program to be offloaded for storage.

I. **Push Button (PB): Duress style button on pedestal used for outdoor intercom. Button activates when emergency release occurs and upon being pressed opens its respective gate. Pedestal is found in intercom specification.**

J. **There are electric key switches at each locally controlled lock in Buildings 1A, 1B, and 2. The activation of a duress switch in these buildings will disable the locally controlled cell door key switches. Coordinate installation with Detention Equipment Contractor (DEC).**

K. Door Chime: Contractor shall furnish and install a Federal Signal Corporation Model AV1-LED Red Audio/Visual signal (or equal) as indicated on the SE drawings. Contractor is to use 24 Volt DC model.

1.03 SYSTEMS INTEGRATION

A. The PLC units shall be integrated with the other systems including, but not limited to:

1. Intercom system.
2. Touchscreen Control Station
3. Access Control system.
4. IP Video system.
5. Event Recording System
6. UPS system.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Acceptable system manufacturers:
1. Accurate Controls
2. CMLRW Security
3. Com-Tec, Inc.
4. Cornerstone Security Electronics
5. Metroplex Control Systems
6. Sierra Detention Systems

Note: Approval as an acceptable system manufacturer does not relieve the manufacturer from furnishing all materials as herein specified.

B. Except as otherwise specified herein, the equipment and materials of this Section shall be products of a single manufacturer engaged in the production of logic control systems for

industrial applications for a minimum of ten (10) years. Controllers manufactured by the following are acceptable:

1. Omron Electronics
2. GE Fanuc
3. Modicon by Schneider Electric
4. Allen Bradley

C. PLC shall be equal to the Omron CS1 series or Modicon 340 series.

D. Industrial Grade Network Switch: Provide a din-rail industrial grade managed Hirschmann RSB20 10/100 Mbps Fast Ethernet switch or equivalent from an approved manufacture. The switch shall provide a redundant network/ ring topology (looping) for the PLC security communications. The switch shall have a minimum of 4 (2 pairs) **SC** MM optic fiber connections and a minimum of six (6) CAT 6A ports dedicated to the PLC network system. Each fiber port and RJ45 port shall be monitored at the PLC/TCS for any failure. Any communication failure shall be monitored on the PLC/TCS as “Comm Failure”. The power to the switch shall be monitored on the PLC for failure as “Comm Power Failure”. Approved manufactures:
1. Hirchmann RSB20 Series is the base design.
2. Cisco.
3. Phoenix Contact.

2.02 GENERAL

A. Programmable logic control system shall control all input/output functions of the TCS station.

B. The programmable logic control system shall be designed so that each PLC operates totally independent of one another. Failure or loss of any controller shall not hamper the operation of any other controller.

C. The programmable controller and I/O modules shall be of modular construction and be capable of being rack mounted.

D. All modules must be key coded to ensure proper slot placement and polarity. All identical function modules shall be coded alike.

E. The controller shall be constructed to withstand as a minimum, the following climatic conditions without the need for special enclosures or additional environmental control equipment such as fans or air conditioning.
1. Temperature: 0 to 60 C (operating), -20 to 70 C (storage)
2. Humidity: 10 to 90% r. h. (non-condensing)

F. Controller shall be capable of operating over a voltage range of 88-132V with a frequency of 45-63 Hz.

G. Controller and I/O racks shall be capable of being front or rear mounted.

H. Where more than one controller is used, all controllers shall be of one single manufacturer and if different size controllers are used, these must be fully compatible.

I. All controllers shall share the same control language and I/O structure.

J. All controller and I/O structures of a single manufacturer shall be capable of being mounted on the same size fixing centers to allow for larger capacity controllers to be installed in the future should the facility require an expansion beyond the limits specified in the original contract documents.

K. Programmable controller manufacturers must guarantee the availability of replacement/spare parts for a minimum of ten (10) years.

L. All input/output modules and housings must be of a standard type and be fully interchangeable with all size controllers.

M. All controllers shall have built-in comprehensive self-test and self-diagnostic capabilities to ensure reliable operation.

N. All controllers shall have built-in status indication of power supply voltages and controller healthy signal to show proper operation.

O. All I/O cards shall be 24V DC and each card shall have as minimum, sixteen (16) discrete circuits. These circuits shall be rated such that they have a minimum of 50% more current capacity than required by the respective I/O devices connected to them.

P. All I/O cards and modules for the unlocking of doors shall be of **the "sourcing" type only.**

Q. Controllers must be capable of driving local I/O racks, where local is defined as up to one hundred (100) feet from the control unit, without the need for further intelligent interface modules or additional power supplies.

R. When required, the system must be capable of controlling remote I/O up to a distance of ten kilometers (10km) from the controller, using high-speed links with a minimum data rate of 1.5 millimeters baud. Communications over this link shall be accomplished using twisted pair wires with an overall shield.

S. Fiber Optic Modules:
   1. Furnish and install all fiber optic modules required for proper system operation.
   2. Modules to be located in PLC CPU rack with continuous fiber through to the next node.
   3. The PLC fiber optic communication link shall be installed in a two fiber self healing "loop" configuration thus eliminating any "single" point of failure from taking down the entire PLC system.

T. In each security electronics room, furnish and install an industrial Ethernet switching hub. Provide sufficient Category 6A ports to connect to each security UPS, each PLC, each TCS, and the ERC.

2.03 FUNCTIONAL REQUIREMENTS

A. The system application program and operating software and fixed database shall be stored in EEPROM.

B. Memory battery backup for general purpose ram shall be for a minimum period of twenty-four (24) months in the event of a power failure.

C. The controllers shall provide all necessary logic functions, timing functions, input points, output points, memory, communication capabilities, and software for the operating features shown in the contract documents.

D. Functions shall include but not be limited to the following which can be implemented in bit logic, word logic, or a mixture of both. The combination of said logic in sufficient levels, variations, and quantities must provide the operating features shown in the contrast documents.

1. Logical AND, OR, XOR and INVERT
2. On/Off Delay
3. Counters
4. Timers
5. Sequencers
6. Four Function Math (Add, Subtract, Multiply, Divide)
7. VCD Input and Output
8. Contacts
9. Coils
10. Block Instructions (conditional jumps)
11. Group Logic Functions
12. Array Math Functions

E. Communications capability shall be provided in logic controllers to allow serial communication between distributed controllers, and ASCII serial devices. Serial communications shall be RS232, RS422, or 20 mA and shall operate at selectable speeds from 300 to 19,200 baud.

F. The logic controllers shall be capable of communication (if required) to other controller via industry standard Ethernet LAN network utilizing non-proprietary protocols.

G. The following modes of operation of the CPU must be selectable via a key operated switch or programming software commands:

1. PROGRAM – Processor is not scanning program in memory and all outputs are held OFF.
2. MONITOR – Processor is executing program and changes in user memory and data memory are allowed.
3. RUN – Processor is executing program in memory and outputs are controlling to the program. No editing of data registers are allowed.

H. The above settings shall require either a key, or programming console with a key, or programming software loaded on a computer to change the operating mode of the CPU.

I. The processor shall incorporate extensive self-diagnostic features that will not half the processor. In addition, separate visual indicators will annunciate at the following conditions.

1. POWER – Logic Power is applied to the CPU and I/O rack from the power supply.

2. RUN – Processor is executing the program in memory and outputs are being controlled according to the program.
3. OUTPUT INHIBIT – Processor is executing program in memory according to input status, but outputs are being held in the OFF state.
4. ALARM – A non-fatal error (such as a low memory battery condition) has occurred in the PLC hardware or program software. The PLC is still running and the outputs are being controlled according to the program.
5. ERROR – A fatal error (such as a memory parity error) has occurred, the CPU is not scanning the program and the outputs are held in the OFF state.

J. In addition to visual self-diagnostic indicators (LED's), the processor shall have a specifically designated block of at least 100 WOR of internal diagnostic words and bits. These shall provide more detailed system status and fault diagnostic information accessible by programming equipment or intelligent peripherals.

K. The processor must contain an error log area. This area must be able to log what error occurred and when the error happened, giving exact time and date. This area must be able to store a minimum of 1000 records.

L. At a minimum, the internal diagnostic registers shall provide the type of digital (input or output) or intelligent (analog, ASCII, etc.) I/O unit inserted in console or programming software.

M. The program storage medium shall be Battery Backed Random Access Memory (RAM). The memory shall be housed in the same enclosure as the processor.

N. Each Network Interface unit for each PLC shall not consume more than one I/O slot in the main PLC rack.

O. The Network Interface units on each of the PLC's shall be powered directly by the terminals located on the rack across the backplane like the other I/O units on that rack. In addition, the Network Interface units shall have auxiliary power supply terminals located on the rack, so that it can be powered separately from some uninterruptable source in the event of a CPU power supply failure.

P. The data rate of the network shall not be less than 2 millions B.P.S. This data rate will remain the same regardless of the number of nodes on the network loop.

Q. The network shall accommodate at least 62 nodes on any network loop.

R. The transmitted data packets from any node must be capable of carrying not less than 512 bytes of data.

S. The PLC and network system shall be designed so that each PLC system will accept at least four Network Interface Units operating simultaneously on their racks.

T. Any node on the network must be able to send data to every other node on the network simultaneously.

U. Using a single command, a network node can communicate with other nodes on three network levels: Nodes on the local network, nodes on the network connected directly via a

gateway/bridge, and nodes on networks separated by one other network (i.e., connected via two network gateways/bridges).

V. The logic control system installed I/O shall be no greater than 80% of the controller's capacity.

W. The logic control system shall be supplied with 20% spare memory capacity available after completion of system software required by the contract documents for future system expansion.

X. Standard PLC communication protocols confirmed by a third party are acceptable for lower level controls. Protocols shall provide a means of supervision to annunciate loss of communication.

2.04 ELECTRONIC CONTROL RELAY SYSTEM

A. The electronic control relay system will perform actual switching of power to locks, intercom, paging, etc. as required and shall be capable of interfacing with other systems. All relays shall be mounted in suitable enclosures with the capability of key lockable doors and removable steel mounting plates if required. The cabinets shall be sized as required to adequately accommodate the equipment housed therein and shall conform to the space requirements indicated on the plans. The cabinets shall be installed as shown on contract drawings.

B. Acceptable Manufactures:

1. Accurate Controls, Ripon, WI; 920-748-6603.
2. CMLRW Security, Erie, CO: 720-466-3650
3. Com-Tec, Inc., Greenville, WI; 920-749-2840.
4. Cornerstone Security Electronics, Decatur. AL; 256-560-4207
5. Metroplex Control Systems, San Antonio TX; 210-495-5245.
6. Sierra Detention Systems, Brighton, CO; 303-278-6879.

C. Class 1 Circuit control Relays: The control relays shall be electro-mechanical type that are rated for at least 50% more current capacity than required for any given steady state control function, but in no case less than 10 amps for power control functions. The relays shall be capable of operating on an input signal of 24 VDC and the output shall be capable of switching the required voltage and current for the intended applications. The unit shall have a minimum of 2500 VAC isolation between the input and output.

D. Class 2 Circuit Control Relays: The control relays shall be electro-mechanical type that are rated for at least 50% more current capacity than required for any given steady state control function, but in no case less than 2 amps for power control functions. The relays shall be capable of operating on an input signal of 24 VDC and the output shall be capable of switching the required voltage and current for the intended applications. The unit shall have a minimum of 2500 VAC isolation between the input and output.

E. Each relay for locking control shall be individually fused to meet California Electric Code distribution requirements and to protect the relay and other circuitry from a short circuit failure at the lock.

F. Each relay rated at 4 amps or higher shall be socket mounted to facilitate field replacement.

G. Provide individual relays for each 120VAC man gate. Locate these relays separately from all other door lock control relays within the equipment rack. Individually fuse each 120VAC current carrying door lock wire with a minimum 4 amp fuse.

H. Indicators on relay base sockets must be rated for the appropriate load. LED indicators on 120VAC relay base sockets are required to function without external resistors, diodes, or other means of draining excess voltage.

I. All relays and terminations are to be clearly labeled to show all field connections.

2.05 TRANSIENT SURGE SUPPRESSION

A. Acceptable manufacturers are as follows:

1. Northern Technologies Incorporated
2. DITEK
3. PolyPhaser Corporation
4. Transtector

B. Miscellaneous Controls: Provide surge protection as indicated on the plans for miscellaneous control circuits that leave the building. Provide surge protectors equal to Northern Technologies series PLP-s units matched to the voltage of the circuit suppressed. The suppressors shall have a peak pulse power dissipation rating of 10 joules each mode, minimum.

C. Security System Power: Provide surge protection for all 120 volt emergency power connections powering logic and control equipment. Device shall be equal to Northern Technologies TCS-HWR series rated for the power of the circuit suppressed. The suppressors shall have a peak pulse power dissipation rating of 300 joules L-N, minimum. Units shall provide a dry contact monitored by the security system and identified by electrical panel circuit number.

D. Clearly identify at each rack location all 120VAC power sources.

2.06 EQUIPMENT ENCLOSURES

A. Acceptable Manufacturers:

1. Cabtron Systems
2. Atlas-Soundolier
3. Hoffman Engineering Co.
4. Hammond Co.
5. CMP Enclosures
6. House of Metal Enclosures, Inc (HOME)

B. Cabinets: Mount equipment in minimum 83” high by 27” deep by 23” wide free standing cabinets as indicated on the plans equal to the Lowell LSER-4427.

1. All racks shall be rated for the seismic requirements of the project, refer to Specification section 280548. Racks shall be constructed of cold rolled steel and provide standard mounting rails for 19" rack mounted equipment.
2. Conduit shall enter from the top.
3. Low voltage wiring shall be separated from 120 volt wiring.
4. PLC equipment may be mounted with intercom or IP video control equipment.
5. Furnish and install solid metal doors for access to both the front and back. Doors shall be minimum 16 gauge flush mounted with air louvers and flush pulls.
6. Side panels shall be a minimum of 16 gauge flush mount.
7. Both front and rear doors shall be provide with key locks.
8. Furnish and install ventilation fans as required to enable proper ventilation for the equipment.
9. Coordinate cabinet power with and Division 26.
10. Furnish and install blank plates by manufacturer to provide closure on all unused rack sections.
11. Furnish and install al seismic supports for computers, monitors, etc.

2.07 DURESS STATION

A. Button: Furnish and install a red mushroom button mounted on a single gang wall plate. Mushroom button shall latch when depressed and require a key reset. Mount at 4 feet above finished floor unless indicated otherwise on plans. If millwork is provided, locate the switch where it is easily accessible by the intended user, but hidden from public view.

B. Switch shall be as follows:

1. Mushroom head key released latching push button equal to IDEC model HW1B-X4F10-R with plastic bezel and one normally CLOSED contact.
2. Mushroom guard shall be equal to IDEC model HW9Z-KG2-TK2120. Furnish and install where indicated on the plans.
3. Faceplate shall be 11 gauge stainless steel attached to box with security screws.

C. Keys: Furnish four duress reset keys for project.

2.08 PUSH BUTTON

A. Push Buton: The push button switch shall be a ceramic-based piezoelectric switch equal to Everswitch SMB series mounted on an 11-gauge stainless steel plate. The switch shall be black with an integral red LED.

B. Push Button Plate: The device plate shall be an 11-gauge stainless steel plate fabricated to mount to a NEMA 4 two-gang box. The plate shall be approximately 4.5 inches square. Secure the plate to the box with four security screws.

C. Controls: Connect the switch to a PLC input. Connect the switch lamp to a PLC output. When the Emergency Release function has been activated, the LED will illuminate and the switch will be active. When the switch is pressed, the gate will open and stay unlocked until emergency release is reset.

D. Pedestals: Furnish and install heavy-duty pedestals for push button stations at gates as indicated on the drawings as PB. Pedestal shall be height adjustable and shall be anchored to a concrete base. Provide hood for push button station. Pedestal shall be constructed of round pipe allowing the housing to spin without breaking if sufficient pressure is applied from the side.

2.09 DOOR MONITOR

A. Where a door is to be monitored, but no detention door position switch is provided, furnish and install a door contact equal to Sentrol 2707A-L hermetically sealed reed switch. Mount to side opposite of the corridor where possible.

B. Unit shall provide a three-foot flexible stainless steel cable. Surface mount sealed switch on the secure side of the door and monitor position.

C. Reed switch shall provide a form C contact and handle up to .25 amps at 30 volts.

D. Reed switch shall function properly with an installed gap of up to three inches.

2.10 Vehicle Loop Detector

A. Acceptable Manufactures:

1. Preferred Security Components Inc.
2. Peek Traffic, Inc. (www.peekglobal.com)
3. National Loop Co.

B. Equipment.

1. Saw-Cut Style Preformed Vehicle Detection Loop: Provide vehicle detection loops as indicated on the plans, National Loop Company SawCut Style Preformed Vehicle Detection Loop, when pavement is already installed. Provide features as follows:
   a. One continuous length of 18 GA XLP or 18GA PVC Insulated, 19 strand wire through loop turns and lead-in.
   b. Machine twisted lead-in with a minimum of 12 turns per foot.
   c. Ease of 45° or even 90° turns in frigid weather.
   d. Loop wires are securely held together with a polypropylene back tape.
   e. Minimum number of turns: 3.0.
2. Pave-Over Style Preformed Vehicle Detection Loop: Provide vehicle detection loops as indicated on the plans, National Loop Company PaveOver Style Preformed Vehicle Detection Loop, when pavement has not been installed. Provide features as follows:
   a. Ribbed non-metallic, ½" flexible conduit covering.
   b. Standard Schedule 40 ½" PVC Type "T" fitting watertight seal.
   c. Accepts standard ½" non-metallic conduit for lead-in protection.
3. Detector Loop Sealant: Provide vehicle detection loop sealant as needed equal to National Loop Company Q-Seal 290. Provide features as follows:
   a. For use in both asphalt and concrete pavements.
   b. Cures in approximately 3 hours at 77°F and 50% R.H.
   c. Chemical resistance to de-icing salts, gasoline, hydraulic brake fluid, motor oil and Calcium Chloride (5%).

4. Single Loop Controller: Provide vehicle loop controllers as indicated on the plans, Peek model 625X Detector. Provide features as follows:
   a. Failsafe or fail-secure outputs.
   b. Six selectable sensitivities.
   c. Second relay output mode selectable.
   d. 24 or 120 VAC input.
   e. Inductance range of 18 to 1800 micro-henries, automatically tuned.
   f. Consistent presence time.
   g. Operating temperature of -40°C to 80°C.
   h. Frequency range of 10 to 97 KHz.
5. Installation: Coordinate installation with all other trades. Coordinate with pavement installation. Furnish and install wire as required by manufacturer.

2.11 CABLING AND WIRE

A. Acceptable manufacturers:

1. Liberty Wire and Cable
2. Eastman Wire & Cable
3. West Penn Wire
4. Belden
5. Carol
6. General Cable
7. Clifford of Vermont, Inc.

B. Wire Size: Furnish and install sufficient wire gauge to limit voltage drop to 5% or less.

C. Listings: Wiring shall be listed for the installation. Wire indicated below is intended to provide electrical characteristic requirements.

D. Duress Station Wiring: Furnish and install a two conductor #22 cable to each duress station. Cable shall be equal to West Penn 220 or AQC290.

E. Push Button Wiring: Furnish and install a four conductor #22 AWG wet rated cable equal to West Penn AQC240.

F. Door Monitor Device Wiring: Furnish and install a two conductor #20 AWG cable to each device. Cable shall be equal to West Penn 222 or AQC292. Cable must be ‘wet location rated’ if routed under the floor slab.

G. Control Wiring: All control wiring within the relay cabinets shall be installed using good workmanship and standard shop wiring and control practices. Conductors shall be grouped and laced with nylon tie straps. Straps will be placed on each side of all bundle breakouts. Wiring will be supported at intervals not exceeding four inches and labeled at both ends. Each relay shall be labeled with its circuit number.

H. Line Voltage Wiring: Line Voltage Wiring that extends from electronic control relay screw terminal strips to the 120 VAC locks; receptacles, etc. shall meet Article 300 of the California Electric Code. All power conductors shall be a minimum 14 AWG THWN, 600 volt rated and shall be installed in raceways and equipment enclosures with other conductors within limitations defined by Article 300 of the California Electric Code.

I. Class 2 Circuit Wiring that extends from the electronic control relay screw terminal strips to the low voltage devices shall be Class 2 as defined by article 725 of the California Electric Code. All control conductors shall be a minimum of 20 AWG, jacketed, control cable. All control cable insulation shall be 600 volt rated.

J. All control wiring shall use stranded copper conductors. All terminations shall be made on screw terminal strips correctly sized and applied to conductor provided.

K. All terminations at devices shall be made with crimp type lugs correctly sized and applied to conductor with crimping tool intended for use with the lug or connector used.

L. All wiring systems shall be labeled and color-coded with labeling and coding shown on shop drawings. White conductors shall be used only for neutral conductors, green only for grounding conductors with exceptions of low voltage control wiring that meet the requirements of Article 725 of the California Electric Code.

M. All conductors within junction boxes pull boxes, and equipment enclosures shall be grouped and laced with nylon tie straps. Attach identification tabs in individual sets serving individual locks or groups. Conductor groups shall be identified on the tab with respect to room or area served.

N. Control system conductors shall not be spliced. All conductors shall be continuous between the control termination point and the controlled device.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Coordination with Other Trades: The ESC shall coordinate the work of this section with that of other Divisions as required to ensure that the entire work of this Project will be carried out in an orderly, complete and coordinated fashion.

B. Field Wiring: The wiring that extends from the electronic control relay screw terminal strips to the locks, lights, etc. shall be class 1, 2, or 3 as defined by Article 725 of the California Electric Code. All conductors shall be 14 gauge or larger THHN or THWN; 600 volt rated, and shall be installed in raceways and equipment enclosures with other conductors, within limitations defined by Article 725 of the California Electric Code.

1. Installation: Dress wires and cables to provide a neat and orderly appearance within all enclosures, equipment racks, cabinets, and consoles by routing in a plastic snap-cover wiring duct. In locations where wiring duct is not feasible, organize by cable clamping, dressing and tie-wrapping.
2. Strain Relief: Relieve strain on all loose wire bundles using tie-wrap supports fastened with machine screws or bolts. Do not use self-adhesive type supports.
3. Shrink Tubing: Neatly form cable ends and apply shrinkable tubing to shielded cables or where necessary to secure the insulation against fraying or raveling.
4. Edge Protection: Install edge protection materials on edges, holes, lips of ducts, or any other place where wires or cables cross sharp metallic edges.

5. Service Loops: Allow sufficient service loops where conductors leave cabinet or transition to door mounted electronics.
6. Splicing: Field wiring shall not be spliced. All wiring shall be continuous from the field device to the termination in the control panel.
7. Wire Termination: All wiring shall be terminated at both ends and labeled in accordance with the equipment wiring plans. Wire not energized or connected to active devices shall be labeled for future use.

C. Ground System: Connection to grounds for Transient Voltage Surge Suppressors shall be 1 ohms or less. All grounds shall be installed as required by the CEC.

D. Ground Wire: Furnish and install a ground wire sized as required by the CEC in all conduits containing conductors carrying voltages above 30 volts rms.

E. Listing: All wiring and raceways shall be listed for the intended installation and installed in strict accordance with the California Electric Code as required by the conditions of where it is stalled. This includes but is not limited to ratings for riser, plenum, or wet installations.

1. All wiring/cabling shall be labeled with the system type and the device ID at each end. The label shall be generated by a Brady I.D. Plus Pro Printer or equal and utilize a Brady part# WML-511-292 label or equal. The label used should allow for the clear part of the label to overlap and protect the printed portion of the label from being exposed to damage and/or being rubbed off over time. Hand written labels are not acceptable. Provide one sample of the labeling to be used on the intercom system, and lock wiring for approval. The numbering system used should match the equipment wiring plans and be similar to the following:
   a. C### camera Cat6.
   b. CA### card access
   c. IC### intercom.
   d. L### locking device. .

F. Vehicle sensor: Completely coordinate the installation of the vehicle sensors with all trades and the owner's representative.

3.02 FABRICATION

A. All cables between racks for PLC inputs and outputs shall be provided with quick release connectors for ease of trouble-shooting and service.

B. Install rack mounted components so they are accessed from the front and/or rear of the cabinet. Do not mount items on the sides of the equipment rack.

C. All field wiring shall be landed on appropriately labeled screw terminal strips.

D. All wiring shall be cabled or neatly bundled and secured to the housing with wire ties and internal wire ducts.

E. Wire nuts, crimp caps and other similar style wire connectors are not acceptable within the equipment racks. All connections within these racks must be done with screw style terminal connections.

3.03 Separation

A. Cabling and conduit shall be installed in strict compliance with the California Electric Code and TIA 569.

B. Communication, Class 2, and Class 3 wires and cables shall be separated by at least 2 inches from conductors of any electric light, electric power, Class 1, non-power-limited fire alarm, or medium power network-powered broadband communications circuits.

1. Separation can be less if communication, Class 2, and Class 3 circuits are completely enclosed in metallic pathways that are properly grounded and bonded per ANSI/TIA-607-B. Walls of the pathway must have a minimum thickness of .04 inches if made of steel or .06 inches if made of aluminum.
2. Separation can be less if any electric light, electric power, Class 1, non-power-limited fire alarm, or medium power network-powered broadband communications circuits are completely enclosed in metallic pathways that are properly grounded and bonded per ANSI/TIA-607-B. Walls of the pathway must have a minimum thickness of .04 inches if made of steel or .06 inches if made of aluminum.

3.04 FIELD QUALITY CONTROL

A. All functions specified shall be individually activated and the result documented. Utilize preprinted test sheets with space for comments and indicate “pass” or “fail” for each. These test reports shall be copied and submitted to the engineer prior to requesting the Engineer to witness the final functional test.

B. All functions shall be demonstrated for the owner and Architects representative.

PLC VERIFICATION AND CHECK-OUT FORM

✓ = OK

Job #
Job Name:
Panel #

FIELD TEST CODE:		**REPAIR CODE:**	
A - No status change	M - Poor audio	1-SSI	Software Test By:_____ Date_____
B - Won't show secure	N - No audio	2-ELECTRICIAN	
C - No power to door	O - Out of focus	3-IRONWORKER	Hardware Test By:_____ Date_____
D - Door won't open	P - No picture	4-CARPENTER	
E - Door won't close	Q - Call button sticks	5-OWNER/REP	System Test By:_____ Date_____
F - Door needs alignment	R - Reversed	6 -ENG	
G - Wrong door opens	S - Software problem	7 -	Design Engineering By:_____ Date_____
H - Adjust DPS	T - Not installed	8 -	
I - Adjust roller bolt	U -	9 -	Wiring By:_____ Date_____
J - File strike plate	V -	10 -	
K - Adjust lock	W -	11 -	Field Test By:_____ Date_____
L - No latch back	X -	12 -	

							ON-SITE				
ICON ID#	**ICON TYPE**	**C/U CAM. NO.**	**DOOR INTLK. WITH**	**CELL GRP. REL.**	**SOFT-WARE TEST**	**HARD-WARE TEST**	**FIELD TEST CODE**	**REPAIR CODE**	**RE-CHECK "X"**	**FIELD CHECK OUT NOTES**	**PROBLEM RESOLVED (BY/DATE)**

3.05 SOFTWARE

A. For each PLC, furnish to the owner uniquely identified:

1. One (1) separate back-up CD or flash memory device for each PLC with the ladder logic file (programmer's notated file) and the source code. Each disk will be labeled with the project name, programs, PLC, programmer, and revision date.
2. One (1) copy of the source code of the application software on CD and/or other digital media.

B. Furnish a single Microsoft Word file detailing all passwords for each PLC. This file shall also identify the following by system and panel:

1. The file name of each program required for restoration of each failed PLC.
2. The passwords required for each PLC as well as required programs.
3. The name of the programmers for each custom program.
4. The date of the last program change.

C. Furnish documents listed in 3.5 A-B at project completion. Furnish a new set with all revisions after the completion of the three month walkthrough outlined in Specification section 280500.

3.06 SPARES

A. The contractor shall turn over to the Owner, the following program documentation and materials:

1. One electronic copy of the source code of the applications software including full instruction documentation and comments on a CD or portable hard drive.
2. All keys, passwords, and access codes for access to the programming software.
3. Furnish one (1) PLC central processor of each type installed.
4. Furnish one (1) Network Ethernet switch for each type installed.
5. Furnish one (1) power supply of each type installed.
6. Furnish one (1) group of programmed memory media for each program installed.
7. Furnish one (1) spare input card of each type installed in the facility.
8. Furnish one (1) spare output card of each type installed in the facility.
9. Furnish one (1) completely assembled duress station.
10. Furnish no less than five (5) of each style of relay used, including relay base.
11. Furnish no less than ten (10) of every size replaceable fuse used.
12. Furnish one (1) Sentrol monitor switch of each type installed on project.
13. Furnish one CPU memory card for each PLC CPU plus 10%.
14. Spare parts shall be packaged in appropriate protective packing material.
15. Box spare parts for easy storage and clearly identify the contents of each box on four sides of each container.

END OF SECTION 284619

DIVISION 31 – EARTHWORK

SECTION 310000 - EARTHWORK

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. This Section include, but is not limited to:
   1. Clearing
   2. Stripping
   3. Soil Remediation
   4. Excavation
   5. Moisture conditioning and compaction
   6. Embankment

1.2 REFERENCES

A. California Building Standards Code (CCR Title 24), 2013 Edition

B. Geotechnical Investigation Preliminary Design Phase For Monterey County New Juvenile Hall by Butano Geotechnical Engineering, dated April 2015, project no. 14-122-M

C. California Code 4216 – Protection of Underground Infrastructure

D. California Occupational Safety and Health Administrative Code

E. Standard Specifications, State of California, Department of Transportation (CalTrans), 2010 Edition

F. ASTM C136 – Standard Test Method for Sieve Analysis of Fine and Course Aggregates

G. ASTM D1556 – Standard Test Method for Density of Soil in Place by the Sand - Cone Method.

H. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3)

I. ASTM D2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate

J. ASTM D2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

K. ASTM 6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

L. ASTM 4829 - Standard Test Method for expansion Index of Soils

1.3 SUBMITTALS

A. Submit samples of proposed imported engineered fill materials to the GEOTECHNICAL ENGINEER. Number and size of samples shall be as directed by the GEOTECHNICAL ENGINEER.

B. Submit gradation and quality testing results for proposed imported engineered fill materials to the ARCHITECT and GEOTECHNICAL ENGINEER.

C. Submit samples and test results at least two weeks prior to planned purchase/delivery.

D. Existing on-site soils will be sampled and tested by the GEOTECHNICAL ENGINEER.

1.4 DEFINITIONS

A. Relative Compaction: Dry density expressed as a percentage of the maximum dry density at optimum moisture content obtained in accordance with ASTM D1557.

B. Remove: Remove and dispose of off-site, in a legal manner.

C. Low Expansion Potential: an expansion index, EI, between 0 to 50 obtained in accordance with ASTM D4829.

PART 2 – PRODUCTS

2.1 MATERIALS

A. General Engineered Fill – Proposed fill material shall be of approved on-site soil supplemented by imported material, if necessary, and in accordance with Section 7.2.2 – General of the project Geotechnical Report
   1. On-site soil shall meet the following requirements:
      a. Soil shall be free of organics (less than 3%), debris, and other deleterious materials
      b. Soil shall be free of rocks and clods over 2.5 inches in maximum dimension
      c. On-site expansive clayey soil may not be used unless chemically altered so it has a low expansion potential
   2. Imported soil shall meet the following requirements:
      a. Soil shall be free of organic and deleterious materials, or recycled materials such as asphaltic concrete, concrete, brick, etc.
      b. Soil shall not contain any rocks or clods over 2.5 inches in maximum dimension, and shall not contain over 15 percent by weight rocks larger than 2 inches.
      c. Soil shall be granular, having a plasticity index of less than 15, and not more than 20 percent by weight passing the #200 seive.
      d. Soil shall have sufficient binder to allow excavations to stand without caving.
      e. The portion finer than the no. 200 sieve shall not contain any expansive clays.
      f. Each proposed source of imported soil shall be sampled, tested and approved by the Geotechnical Engineer prior to delivery to the site.

B. Controlled Density Fill – Slurry cement backfill conforming to Section 19-3.062 of the Standard Specifications.

PART 3 – EXECUTION

3.1 GENERAL

A. All work shall be performed in conformance with the California Building Code, the Geotechnical Report, the Construction Drawings, and these Specifications.

B. Onsite grading and earthwork, site preparation, excavation, trenching and compaction shall be observed and tested by the GEOTECHNICAL ENGINEER. All grading and earthwork shall be done to the satisfaction of the GEOTECHNICAL ENGINEER.

C. Provide dust control to satisfaction of the OWNER and in accordance with all federal, state, and local requirements.

D. In the event that any unusual conditions are encountered during grading operations which are not covered by the Geotechnical Report or these Specifications, the GEOTECHNICAL ENGINEER shall be immediately notified such that additional recommendations may be made.

3.2 PREPARATION:

A. Layout all work, establish grades, locate existing underground utilities, set markers and stakes, set up and maintain barricades and protection for utilities, benchmarks, paving, site features, and the public.

B. Excavation for any purpose shall not remove lateral support from any foundation without first underpinning or protecting the foundation against settlement or lateral translation. The excavation outside the foundation shall be backfilled with soil that is free of organic material, construction debris, cobbles and boulders or with a controlled low-strength material (CLSM). The backfill shall be placed in lifts and compacted in a manner that does not damage the foundation or the waterproofing or damp-proofing material.

3.3 CLEARING AND STRIPPING:

A. Remove structures, pavements, and utilities as shown on the Drawings.

B. Areas to be graded shall be cleared of all grass, brush, trees, rubbish, and debris. The cleared materials shall be removed from areas to be graded and shall be disposed of in areas designated by the Owner.

C. Completely remove tree stumps and root balls in areas to receive pavements, structures, or engineered fill to the satisfaction of the Geotechnical Engineer.

D. Upper natural soils containing roots, deleterious materials, and excessive organics shall be stripped from all areas to be graded. This material shall not be reused as compacted fill and shall either be removed from the site or stockpiled for later use in landscape areas.

E. Unanticipated buried subsurface objects encountered, or voids created during site preparation, shall be called to the attention of the geotechnical engineer.

3.4 SOIL REMEDIATION

A. In areas of undocumented fill as delineated on the project plans, the non-engineered fill shall be over-excavated down to in-situ soil as determined by the Geotechnical Engineer. The undocumented fill material may be re-used as engineered fill following section 7.2.2-general of the project geotechnical report. Any potentially expansive soil encountered during grading shall require chemical treatment for re-use, or be off-hauled.

B. Conventional shallow foundations and non-structural slab-on-grades shall be founded on a minimum of 24 inches of non-expansive engineered fill per section 7.2.2-general of the project geotechnical report. The non-expansive fill shall consist of imported soil, on-site non-expansive soil, or chemically altered on-site soil. The non-expansive fill shall be compacted to a minimum of 90 percent relative compaction.

C. Chemically altering the soil shall consist of lime treating the soil to minimize its swell potential. Testing of the soil to determine the appropriate mix ratio and ensure that the soil reacts is required. Lime stabilized soil shall be in accordance with Section 24 of the Caltrans Standard Specifications. Lime shall be added to the material to be stabilized at a rate of 4% (percent) by weight of the dry material. The exact rate is ordered based on achieving an unconfined compressive strength of the lime stabilized material of 300 psi, determined under California Test 373.

D. Exterior slab-on-grades shall be founded on a minimum of 24 inches of either chemically altered soil (lime treatment), non-expansive on-site soil, or imported engineered fill per section 7.2.2-general of the project geotechnical report. Exterior slab-on-grades shall be physically separated from the structure.

3.5 EXCAVATION, MOISTURE CONDITIONING, AND RECOMPACTION

A. Following clearing and stripping and soil remediation, the subgrade shall be cut and finished true to line and grade, to present a smooth surface free from ruts, hummocks or other uneven features which would tend to prevent uniform compaction.

B. The exposed subgrade shall then be scarified, moisture conditioned, and recompacted to at least 90% relative compaction.

C. When the moisture content of the subgrade is below the desired moisture, water shall be added until the proper moisture content is achieved.

D. When the moisture content of the subgrade is too high to permit the specified compaction to be achieved, the subgrade shall be aerated by blading, ripping, disking or other methods until the moisture content is satisfactory for compaction.

3.6 PLACING, SPREADING, AND COMPACTING FILL MATERIAL:

A. The geotechnical engineer shall inspect all surfaces to receive fill prior to the placement of fill.

B. Fill shall be placed in horizontal layers not exceeding eight inches (8") in loose thickness (before compaction). Each layer shall be spread evenly and shall be thoroughly mixed during the spreading to promote uniformity of material in each layer.

C. All re-compacted and engineered fill soils shall be compacted within 2 percent of the laboratory optimum moisture content for the soil

D. When the moisture content of the fill material is below the proper moisture, water shall be added until the proper moisture content is achieved.

E. When the moisture content of the fill material is too high to permit the specified degree of compaction to be achieved, the fill material shall be aerated by blading, ripping or disking or other methods until the moisture content is satisfactory.

F. After each layer has been placed, mixed and spread evenly, it shall be thoroughly compacted to at least 90% relative compaction.

G. Compaction shall be undertaken with equipment capable of achieving the specified density and shall be accomplished while the fill material is at the required moisture content. Each layer shall be compacted over its entire area until the required density has been obtained.

H. Fill slopes shall be compacted by slope rolling and trimming, or shall be overfilled and trimmed back to planned grade.

I. The filling operations shall be continued until the fills have been brought to the finished slopes and grades as shown on the Drawings.

J. Fill slopes shall be no steeper than 2:1 (horizontal to vertical), unless shown otherwise in the Construction Documents.

K. The completed fill shall be finished true to line and grade. Any depressions shall be filled and compacted and all loose material shall be removed.

3.7 KEYING AND BENCHING

A. Where existing grade is at a slope of 5H:1V (20%) or steeper, a toe key and benching shall be provided.

B. The toe key shall be cut a minimum depth of 2 feet into undisturbed soils. The keyway shall be 10 feet in width, or one-half the slope height, whichever is greater, and shall slope at no less than 5% into the slope.

C. As the fill advances up-slope, benches at least 3 feet wide, or twice the width of the compaction equipment, whichever is wider, shall be scarified into the fill/undisturbed soil interface.

3.8 SUBGRADE PREPARATION IN PAVEMENT AREAS:

A. Pavement Areas are exterior areas which are not in the building subgrade preparation area and which will receive asphalt or concrete pavement or other flatwork, including parking lots, driveways, access roads, concrete grid pavements (grass pavers), equipment slabs, curbs, gutters, or sidewalks.

B. Subgrade preparation in pavement areas shall be in accordance with the Geotechnical Report and as directed by the GEOTECHNICAL ENGINEER.

C. Subgrade preparation shall extend at least 1 foot beyond the edge of asphalt concrete paving areas.

D. Subgrade preparation shall extend at least 1 foot beyond the edge of concrete slab and concrete grid pavement areas.

E. The upper 6 inches of subgrade in pavement areas shall be compacted to at least 95 percent relative compaction.

F. Exterior slabs on grade and concrete grid pavement shall be founded on a minimum of 24 inches of either chemically altered soil (lime treatement), non-expansive on site soil or imported engineered fill per section 7.2.2 – General of the project Geotechnical Report. Exterior slab on grades shall be physically separated from the structure.

3.9 SUBGRADE PREPARATION IN BUILDING AREAS:

A. Subgrade preparation in the building and other structure areas shall be in accordance with the Geotechnical Report and as directed by the GEOTECHNICAL ENGINEER.

B. Subgrade preparation shall extend to at least 3 feet beyond the edge of new buildings and structures.

C. Concrete slab on grades shall be founded on a minimum of 24 inches of either non-expansive engineered fill or chemically altered (lime treated) in-situ soil per section 7.2.2 of the project Geotechnical Report.

3.10 SURPLUS MATERIAL

A. Surplus material shall become the property of the CONTRACTOR and shall be disposed of off the site in a legal manner.

3.11 TESTING AND OBSERVATION

A. Testing shall be performed by the GEOTECHNICAL ENGINEER and shall be in accordance with the provisions as outlined in Section 6 of the Caltrans Construction Manual.
B. The GEOTECHNICAL ENGINEER will inspect all surfaces to receive fill prior to the placement of any fill.
C. The GEOTECHNICAL ENGINEER will make field density tests after compaction of each layer of fill or as determined necessary. Additional layers of fill shall not be spread until the field density tests indicate that the minimum specified density has been obtained.
D. Should the result of any compaction test fail to meet the minimum required density as specified in these Specifications or in the Geotechnical Report, the deficiency shall be corrected to the satisfaction of the GEOTECHNICAL ENGINEER, at the contractor's expense. The expense of retesting such areas shall also be borne by the contractor.

END OF SECTION 312200

SECTION 312333 - TRENCHING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Trench excavation, shoring, and dewatering
B. Pipe bedding, installation, and alignment
C. Concrete encasement
D. Concrete thrust blocks
E. Warning tape and tracer wire
F. Trench backfilling and compaction
G. Surface restoration
H. Record drawing requirements

1.2 REFERENCES

A. California Building Standards Code (CCR Title 24)
B. Standard Specifications, State of California, Department of Transportation (CalTrans), 2010 Edition.
C. California Code 4216 – Protection of Underground Infrastructure
D. California Occupational Safety and Health Administrative Code
E. Geotechnical Report: Geotechnical Investigation Design Phase for Faculty Row Housing Project, Monterey, California. Butano Geotechnical Engineering, Inc., September 2011, Proj No. 11-116-M
F. ASTM C 136 – Standard Test Method for Sieve Analysis of Fine and Course Aggregates
G. ASTM D1556 – Standard Test Method for Density of Soil in Place by the Sand - Cone Method
H. ASTM D 1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3)
I. ASTM D 2321 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
J. ASTM D 2419 – Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
K. ASTM D 2487 – Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
L. ASTM D 6938 – Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
M. ASTM F 1668 – Standard Guide for Construction Procedures for Buried Plastic Pipe.

1.3 SAFETY

A. Work shall comply with all federal, state, and local safety requirements
B. Except by permission of the OWNER, no trench shall remain open overnight

PART 2 - PRODUCTS

2.1 MATERIALS

A. Pipe: as specified for the utility being installed.

B. Foundation, bedding and backfill materials shall be as noted on the Plans and as specified for the type of facility being installed.

C. If not otherwise specified, foundation, bedding and initial backfill shall be Clean Sand, as defined herein. Native material may only be used if approved by the GEOTECHNICAL ENGINEER.

D. Concrete encasement: Minor Concrete conforming to Section 64 of the Standard Specifications.

E. Concrete thrust blocks: Minor Concrete conforming to Section 64 of the Standard Specifications.

F. Controlled density fill: Slurry Cement Backfill conforming to Section 19 of the Standard Specifications.

G. Aggregate base: Class 2 Aggregate Base conforming to Section 26 of the Standard Specifications.

H. Clean Sand: Natural river or bank sand; free of silt, clay, loam, friable or soluble materials, or organic matter; maximum particle size and volume of 1/2 inch and 18 percent respectively, with minimum Sand Equivalent value of 30 per California Test 217 or ASTM D2419

I. Select native material may be used for bedding and/or backfill only if approved by the GEOTECHNICAL ENGINEER.

2.2 SUBMITTALS

A. Submit proposed foundation, bedding, and backfill materials to the GEOTECHNICAL ENGINEER at least 2 weeks prior to planned delivery or use.

B. Submit manufacturer’s cut sheets for all other materials to the ARCHITECT.

2.3 ACCESSORIES

A. Detection tape: Polyethylene plastic warning tape, minimum 3.5 mils thick, 6" wide, appropriately labeled and color coded.

B. Tracer wire: Insulated No. 12 copper wire

C. Geotextile fabric: in accordance with Section 88 of the Standard Specifications and as approved by the GEOTECHNICAL ENGINEER.

PART 3 - EXECUTION

3.1 GENERAL

A. Perform work in accordance with:
   1. Section 31 00 00, “Earthwork”
   2. California Building Standards Code
   3. Geotechnical Report
   4. Drawings
   5. Product manufacturers’ recommendations

B. Where work is performed in public streets or rights of way, or on public utilities, perform the work in accordance with the requirements of the authority having jurisdiction and/or utility owner, if such requirements are more stringent than the requirements of this section.

3.2 PROTECTION

A. Protect trees, shrubs, lawns, rock outcropping, and other landscape features to remaining as portion of final landscaping.

B. Protect benchmarks, existing structures, fences, roads, sidewalks, paving, curbs and other improvements to remain.

C. Protect above and below grade utilities which are to remain.

D. Document all pre-existing surface defects by photographic means prior to conducting trenching operations. Upon completion of construction, all surfaces showing non-documented settlement, spalls, gouges, cracks or other defects shall be repaired or replaced to the satisfaction of the ARCHITECT.

E. Return all surface improvements designated to remain, which are removed for excavation, to their original condition, except as required to comply with other portions of the contract.

F. Utility trenches which are parallel to the side of a footing shall be placed so that the trench bottom does not extend below a plane sloping downward and away from the building/footing at an inclination of 2:1 (H:V) from the bottom outside edge of the footing.

3.3 POTHOLING

A. Pothole utility lines in advance of construction to determine if adjustment in horizontal or vertical location of pipe line is required. Submit drawing to Architect showing located utility locations and elevations.

B. If potholing indicates a conflict between existing and proposed facilities, notify the ARCHITECT immediately. Do not perform work on systems which may be affected by the conflict until a resolution has been reached and you have been notified by the ARCHITECT.

3.4 EXCAVATION, BEDDING, PIPE PLACEMENT, AND BACKFILLING

A. Trenching
   1. Excavate to the lines and grades indicated on the Drawings. The OWNER reserves the right to make changes to lines, grades, and depths when required due to field conditions.
   2. The excavation and the preparation of the trench shall be completed a sufficient distance in advance of pipe laying to prevent dislodged material from entering the pipe.
   3. If the foundation soil is soft, wet, spongy or unstable, the trench shall be excavated to stable soil as determined by the Geotechnical Engineer, and the excavation backfilled with pipe bedding material.

B. Shoring
   1. The sides of all excavations shall be laid back or supported in the manner set forth by CAL/OSHA.
   2. Sheet piling and other shoring shall be withdrawn in such a manner as to prevent caving of the walls of excavations or damage to piping or other structures.
   3. Whenever timber or other sheeting is driven to a depth below the elevations of the top of the pipe, that portion of the sheeting below the elevation of the top of the pipe shall not be disturbed or removed.

C. Dewatering
   1. Remove all water which may accumulate in the excavation during progress of the work so that all work can be done under dry conditions. Trenches shall be kept free from water while the pipe or other structures are installed, while concrete is setting, and until backfill has progressed to a sufficient height to anchor the work against possible flotation or leakage.
   2. Dewatering shall conform to the best management practices as outlined in the California Stormwater Quality Association's *Stormwater Best Management Practice Handbook: Construction*, latest edition.

D. Pipe bedding
   1. A minimum of 6" bedding below the pipe shall be placed in such a manner that the pipe may be laid true to line and grade. When the pipe is bedded, it shall be brought into true alignment and secured.
   2. Place and compact the initial backfill material to the pipe spring line in maximum 8 inch lifts. Carefully compact this material around and under the pipe.
   3. Place and compact the initial backfill material to 12 inches above the top of the pipe in maximum 8 inch lifts. Carefully compact this material around and under the pipe.
   4. Place and compact final trench backfill material in maximum 8" lifts to the final grade or subgrade elevation.
   5. Bedding and backfill shall be compacted to at least 95 percent relative compaction in improved areas, and 90 percent in landscaped or unimproved areas.
   6. Where slurry cement is utilized for pipe bedding, the pipe shall be set on precast mortar blocks or similar devices to allow for placement of required thickness of material under and around the pipe. The Contractor take the necessary steps to avoid pipe flotation or mis-alignment.

E. Pipe Installation:
   1. Pipe installation shall be in accordance with the manufacturer's instructions.

2. All pipe handling shall be done in a manner that will not damage the materials. Pipe shall be carried into position, not dragged, and shall be carefully lowered into the trench. Under no circumstances shall the pipe or accessories be dropped into the trench.
3. Before lowering into the trench, and while suspended, the pipe shall be inspected for defects. Any defective, damaged or unsound pipe shall be rejected and replaced with sound material. The interior of the pipe shall be clean and free of debris.
4. Joints shall be centered and tight. Cutting of pipe for inserting fittings or for pipe connections shall be done in a neat and skillful manner without damage to the pipe. Each joint shall be inspected to insure it is properly made before backfilling is done.
5. The pipe shall be laid true to line and grade. When completed, the pipe shall have a smooth and uniform invert. Care shall be taken to prevent any dirt or foreign matter from entering the open end of the pipe.
6. Where piping is installed on curves, the maximum deflection of each joint shall be no more than 80 percent of the maximum deflection recommended by the pipe manufacturer.

F. Trench Backfill and Compaction:
1. All backfill shall be placed in a manner to avoid rock pockets, voids, or other conditions that could lead to future settlement of the backfill.

3.5 TEMPORARY PIPE COVER

A. Provide temporary backfill or other means as necessary to protect underground utilities from heavy construction loads.

3.6 CONTROLLED DENSITY FILL (CDF)

A. Backfill trenches with CDF where trenches cross below footings, including perimeter footings. CDF plug shall be a minimum of 3 feet long, and shall extend a minimum of 1 foot beyond the edge of footing.

B. Backfill trenches with CDF where pipes are “nested” in clusters where adequate compaction cannot be achieved between and around the pipes, and at all pipe connections, valves, utility vaults, etc. where adequate compaction cannot be achieved by mechanical means.

C. Backfill other areas with CDF where indicated on the Construction Drawings and as directed by GEOTECHNICAL ENGINEER.

D. If pipe will be partly or entirely embedded in CDF, support and brace the pipe in a manner that will prevent movement or displacement of the pipe during testing and during placement and consolidation of the slurry backfill. Consolidate CDF under and around the pipe without displacing the pipe.

3.7 CONCRETE BACKFILL

A. Place concrete backfill where indicated on the Construction Drawings.

B. If pipe will be partly or entirely embedded in concrete, support and brace the pipe in a manner that will prevent movement or displacement of the pipe during testing and during placement and consolidation of the concrete. Consolidate concrete under and around the pipe without displacing the pipe.

3.8 THRUST BLOCKS

A. Concrete thrust blocks shall be installed on pressure piping as indicated by the details on the Construction Drawings.

B. Blocking shall be placed between undisturbed solid ground and the fitting to be anchored with the base and effective thrust bearing side of the thrust block poured against undisturbed earth. The sides of the thrust block not subject to thrust may be poured against forms.

C. Blocking shall be placed so that fitting joints will be accessible for repair.

D. Thrust blocks shall be poured and allowed time to set before pressure testing the piping.

E. Notify the ARCHITECT prior to pouring thrust blocks.

3.9 BURIED WARNING AND IDENTIFICATION TAPE

A. Provide metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3 inch minimum width, color coded as specified below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Provide permanent color and printing, unaffected by moisture or soil.

WARNING TAPE COLOR CODES

RED:	ELECTRIC
YELLOW:	GAS, OIL; DANGEROUS MATERIALS
ORANGE:	TELEPHONE AND OTHER COMMUNICATIONS
BLUE:	WATER SYSTEMS
GREEN:	SEWER SYSTEMS
WHITE:	STEAM SYSTEMS
GRAY:	COMPRESSED AIR

B. Warning Tape for Metallic Piping: Provide acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.003 inch and a minimum strength of 1500 psi lengthwise, and 1250 psi crosswise, with a maximum 350 percent elongation.

C. Detectable Warning Tape for Non-Metallic Piping; Provide polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.004 inch, and a minimum strength of 1500 psi lengthwise and 1250 psi crosswise. Manufacture tape with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 3 feet deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

3.10 TRACER WIRE

A. Tape continuous tracer wire on top of and along entire length of pipes and extend to the grade at each end of the utility pipe so locator equipment can be connected.

B. Install tracer wire on:
   1. All exterior gas piping
   2. Exterior nonmetallic pressure piping (water, recycled water, and sewer force mains), 4”-diameter and greater

3.11 SURFACE RESTORATION

A. Any pavement, curb, walk or any other surface or subsurface improvement removed or damaged during progress of the work, shall, before termination of the contract, be restored to its original condition whether or not such restoration is indicated on the Construction Drawings.

END OF SECTION 312333

DIVISION 32 – EXTERIOR IMPROVEMENTS

SECTION 321123 - AGGREGATE BASE COURSE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Aggregate base course.

1.2 REFERENCES

A. Standard Specifications, State of California, Department of Transportation (Caltrans), 2010 edition.

B. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3).

C. ASTM D1556 – Standard Test Method for Density of Soil in Place by the Sand - Cone Method

D. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1.3 SUBMITTALS

A. Results of laboratory testing for gradation, R-value, Sand Equivalent, and Durability Index in accordance with Section 26 of the Standard Specifications.

B. Materials certificates signed by material producer and Contractor, certifying that each material item complies with, or exceeds, specified requirements.

C. This project has a LEED requirement for recycled aggregate base: submit invoices and documentation from supplier indicating percentages (by weight) of post-consumer and pre-consumer recycled content. Include material costs (taxes, fees, shipping, labor, profit, etc. not included) for each product having recycled content.

D. This project has a LEED requirement for local aggregate base: Submit invoices and documentation indicating location of manufacture and locations of extraction and/or harvest for each raw material sourced within 500 miles of the project site. Indicate method of calculating distance from location to project site.

PART 2 - PRODUCTS

2.1 CLASS 2 AGGREGATE BASE

A. Class 2 Aggregate Base per Section 26 of the Standard Specifications.
   1. This project has a LEED requirement for aggregate base: At least 20% of the Aggregate Base shall be recycled material (post-consumer plus 1/2 pre-consumer) conforming to the Standard Specifications.

PART 3 - EXECUTION

3.1 SUBGRADE

A. Prepare subgrade as specified in Section 31 00 00.

B. Sprinkle the subgrade regularly to moisten the surface and to prevent it from drying out and/or cracking prior to the placement of aggregate base.

3.2 SPREADING AND COMPACTING

A. Deliver base course to site as uniform mixtures.

B. Place aggregate base in accordance with Section 26 of the Standard Specifications.

C. Compact aggregate base to at least 95 percent relative compaction as determined by ASTM D1557.

D. The GEOTECHNICAL ENGINEER will field test subgrade and aggregate base course compaction.

END OF SECTION 321123

SECTION 321123 - AGGREGATE BASE COURSE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Aggregate base course.

1.2 REFERENCES

A. Standard Specifications, State of California, Department of Transportation (Caltrans), 2010 edition.

B. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3).

C. ASTM D1556 – Standard Test Method for Density of Soil in Place by the Sand - Cone Method

D. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1.3 SUBMITTALS

A. Results of laboratory testing for gradation, R-value, Sand Equivalent, and Durability Index in accordance with Section 26 of the Standard Specifications.

B. Materials certificates signed by material producer and Contractor, certifying that each material item complies with, or exceeds, specified requirements.

C. For recycled aggregate base (for projects seeking LEED certification): submit invoices and documentation from supplier indicating percentages (by weight) of post-consumer and pre-consumer recycled content. Include material costs (taxes, fees, shipping, labor, profit, etc. not included) for each product having recycled content.

D. For local aggregate base (for projects seeking LEED certification): Submit invoices and documentation indicating location of manufacture and locations of extraction and/or harvest for each raw material sourced within 500 miles of the project site. Indicate method of calculating distance from location to project site.

PART 2 - PRODUCTS

2.1 CLASS 2 AGGREGATE BASE

A. Class 2 Aggregate Base per Section 26 of the Standard Specifications.
   1. For projects seeking LEED certification: At least 20% of the Aggregate Base shall be recycled material (post-consumer plus 1/2 pre-consumer) conforming to the Standard Specifications.

PART 3 - EXECUTION

3.1 SUBGRADE

A. Prepare subgrade as specified in Section 31 00 00.

B. Sprinkle the subgrade regularly to moisten the surface and to prevent it from drying out and/or cracking prior to the placement of aggregate base.

3.2 SPREADING AND COMPACTING

A. Deliver base course to site as uniform mixtures.

B. Place aggregate base in accordance with Section 26 of the Standard Specifications.

C. Compact aggregate base to at least 95 percent relative compaction as determined by ASTM D1557.

D. The GEOTECHNICAL ENGINEER will field test subgrade and aggregate base course compaction.

END OF SECTION 321123

SECTION 321216 - ASPHALT CONCRETE PAVING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Hot Mix Asphalt (HMA) concrete pavement

1.2 REFERENCES

A. Standard Specifications, State of California, Department of Transportation (Caltrans), 2010 edition.

1.3 SUBMITTALS

A. Hot mix asphalt mix design prepared by a certified laboratory

B. Materials certificates signed by material producer and Contractor, certifying that each material item complies with, or exceeds, specified requirements

PART 2 - PRODUCTS

2.1 HOT MIX ASPHALT

A. 3/4-inch HMA Type A in accordance with Section 39 of the Standard Specifications.
   1. Construction Process: Standard.
   2. Tack Coat: as required by the Standard Specifications
   3. Asphalt Binder: PG 64-10 (Monterey County)

PART 3 - EXECUTION

3.1 GENERAL

A. Perform work in accordance with Section 39 of the Standard Specifications.

B. Equipment, methods and tolerances used for spreading and compacting HMA shall comply with the requirements of Standard Specifications.

C. Finish paving shall conform to slopes, lines and finish grades shown and noted on the Construction Drawings and shall drain properly.
   1. Maintain line and profile shown on the Construction Drawings to tolerance of 1/4 inch plus/minus, in any 10 feet, non-cumulative.
   2. HMA surface shall be free from depressions exceeding 1/8 inch when measured with a 10 foot straight-edge.

D. Surface shall be free of gouges, ridges and ruts, with a uniform and consistent finish.

E. Where adjacent surfaces are intended to be flush, they shall conform smoothly at all points with no greater than 1/4 inch grade differential, shall drain properly across the seam.

3.2 FIELD QUALITY CONTROL

A. Field density and thickness testing of asphalt pavement will be performed by the GEOTECHNICAL ENGINEER.

B. Flood Test:
1. Perform a flood test in areas which are sloped less than 3%. Where a seal coat is to be applied, perform flood test prior to application of seal coat.
2. Where water ponds in excess of 1/8 inch deep or in an area greater than 2 feet in any direction, or where the drainage pattern does not conform to the intent of the Construction Drawings, repair or replace HMA as directed by the ARCHITECT to provide proper drainage, at no cost to the OWNER.

3.3 PROTECTION

A. Do not permit vehicular traffic on pavement until it has cooled to atmospheric temperature and hardened, but in no case less than 8 hours.

B. Do not use completed paving surface for storage of construction vehicles or construction materials.

C. Gouges, cracks, stains, or other surface defects or marks shall be corrected by the CONTRACTOR in a manner acceptable to the ARCHITECT, at no cost to the OWNER.

END OF SECTION 321216

SECTION 321216 - ASPHALT CONCRETE PAVING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Hot Mix Asphalt (HMA) concrete pavement

1.2 REFERENCES

A. Standard Specifications, State of California, Department of Transportation (Caltrans), 2010 edition.

1.3 SUBMITTALS

A. Hot mix asphalt mix design prepared by a certified laboratory

B. Materials certificates signed by material producer and Contractor, certifying that each material item complies with, or exceeds, specified requirements

PART 2 - PRODUCTS

2.1 HOT MIX ASPHALT

A. 3/4-inch HMA Type A in accordance with Section 39 of the Standard Specifications.
   1. Construction Process: Standard.
   2. Tack Coat: as required by the Standard Specifications
   3. Asphalt Binder: PG 64-10 (Monterey County)

PART 3 - EXECUTION

3.1 GENERAL

A. Perform work in accordance with Section 39 of the Standard Specifications.

B. Equipment, methods and tolerances used for spreading and compacting HMA shall comply with the requirements of Standard Specifications.

C. Finish paving shall conform to slopes, lines and finish grades shown and noted on the Construction Drawings and shall drain properly.
   1. Maintain line and profile shown on the Construction Drawings to tolerance of 1/4 inch plus/minus, in any 10 feet, non-cumulative.
   2. HMA surface shall be free from depressions exceeding 1/8 inch when measured with a 10 foot straight-edge.

D. Surface shall be free of gouges, ridges and ruts, with a uniform and consistent finish.

E. Where adjacent surfaces are intended to be flush, they shall conform smoothly at all points with no greater than 1/4 inch grade differential, shall drain properly across the seam.

3.2 FIELD QUALITY CONTROL

A. Field density and thickness testing of asphalt pavement will be performed by the GEOTECHNICAL ENGINEER.

B. Flood Test:
1. Perform a flood test in areas which are sloped less than 3%. Where a seal coat is to be applied, perform flood test prior to application of seal coat.
2. Where water ponds in excess of 1/8 inch deep or in an area greater than 2 feet in any direction, or where the drainage pattern does not conform to the intent of the Construction Drawings, repair or replace HMA as directed by the ARCHITECT to provide proper drainage, at no cost to the OWNER.

3.3 PROTECTION

A. Do not permit vehicular traffic on pavement until it has cooled to atmospheric temperature and hardened, but in no case less than 8 hours.

B. Do not use completed paving surface for storage of construction vehicles or construction materials.

C. Gouges, cracks, stains, or other surface defects or marks shall be corrected by the CONTRACTOR in a manner acceptable to the ARCHITECT, at no cost to the OWNER.

END OF SECTION 321216

SECTION 321313 - CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY:

A. This section includes exterior concrete paving including curbs, gutters, sidewalks, walkways, and patios.

1.2 REFERENCES

A. Standard Specifications, State of California, Department of Transportation (Caltrans), 2010 edition.

1.3 SUBMITTALS

A. Concrete mix design and testing results

B. Proposed scoring pattern, if not indicated on the Construction Drawings

C. Manufacturers' current printed specifications and catalogue cuts of the following:
   1. Expansion joint filler, backer rod and bond breaker and/or zip strip.
   2. Integral color
   3. Joint Sealant Color Sample

D. Submit sample chip of specified color, if called for on the project plans, indicating pigment number and required dosage rate. Submittals are for general verification of color and may vary somewhat from concrete finished in field according to Specifications.

1.4 QUALITY ASSURANCE

A. Mock-Up:
   1. Provide full-scale mock-up under provisions of Section 014000. Construct at least two months before start of concrete work. Allow concrete to cure 28 days before observation.
   2. At location on Project selected by Architect, demonstrate each forming and finishing condition required on Project using materials, workmanship, joint treatment, form ties, curing method, and patching techniques to be used throughout Project. Paving mock-ups shall be a minimum 4-foot x 4-foot for each type of finish.
   3. Accepted mock-up provides visual standard for work of Section.
   4. Mock-up may remain as part of Work

B. The GEOTECHNICAL ENGINEER will perform concrete compression tests and other quality control testing and inspection as indicated.

PART 2 - PRODUCTS

2.1 CONCRETE:

A. Concrete shall conform to the requirements for “Concrete Curbs and Sidewalks” as described in Section 73 of the State of California Department of Transportation Standard Specifications.

B. Concrete must contain at least 505 pounds of cementitious material per cubic yard.

C. Water to cement ratio shall be 0.50 or less.

2.2 REINFORCEMENT

A. ASTM A615, grade 40 for #3 and smaller bars and grade 60 for #4 and larger bars

2.3 ACCESSORIES

A. Expansion Joint Material
   1. Premolded Joint Filler: ASTM D1751, non-extruding and bituminous type resilient filler, compatible with sealant and backer rod.
   2. Sealant Backer Rod:
      a. Type: Compressible polyethylene foam rod or other flexible, permanent, durable non-absorptive material as recommended by joint sealer manufacturer for compatibility with joint sealer.
      b. Product: "Sonofoam Backer-Rod" as manufactured by Sonneborn Building Products, or approved equal.
   3. Snap Cap: Seal tight Snap Cap by W.R. Meadows or approved equal.
   4. Joint Sealer
      a. Type: Multi-component polyurethane sealant, FS TT-S-00227, Class A, type as recommended by manufacturer for exterior locations subject to foot traffic.
      b. Product: ASTM C290, non-snag sealant "Dynatred" by Pecora Corporation, or "Sonolastic Sealant NP1 & NP2" by Sonneborn, or approved equal.
      c. Color: Submit Samples
   5. Bond Breaker: Polyethene tape as recommended by joint sealant manufacturer where bond to joint filler must be avoided for proper performance of joint sealer.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Concrete curbs: Construct in accordance with the Standard Specifications and as indicated on the Construction Drawings.

B. All concrete curbs must be completed and backfilled before asphalt concrete is placed.

C. Concrete installation and finish: Conform to the requirements of the Standard Specifications or as indicated on the Construction Drawings.

D. All exposed faces shall be finished. Faces in planter areas shall be finished to at least 6" below finish grade.

E. Saw Cut Joints
   1. Do not sawcut until seven (7) days after installation of slab.
   2. Cutting: Using accepted mechanical concrete saw. Employ only experienced personnel. Perform all cuts cleanly and smoothly, to a constant and equal depth. Perform in as continuous an operation as possible to avoid misalignment of joints. Use forms or templates as required to achieve consistent lines.
   3. Controls: Accurately align joints with all adjacent improvements.
   4. Protection: Protect all adjacent site improvements during construction of this work. Repair all damage to the satisfaction of the Architect and at no additional cost to Owner.

3.2 FINISHES
   1. Concrete finishes shall be as indicated on the project plans.

END OF SECTION 321313

SECTION 321313 - CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY:

A. This section includes exterior concrete paving including sidewalks, walkways, and patios.

1.2 REFERENCES

A. Standard Specifications, State of California, Department of Transportation (Caltrans), 2010 edition.

1.3 SUBMITTALS

A. Concrete mix design and testing results

B. Proposed scoring pattern, if not indicated on the Construction Drawings

C. Manufacturers' current printed specifications and catalogue cuts of the following:
   1. Expansion joint filler, backer rod and bond breaker and/or zip strip.
   2. Integral color
   3. Joint Sealant Color Sample

D. Submit sample chip of specified color indicating pigment number and required dosage rate. Submittals are for general verification of color and may vary somewhat from concrete finished in field according to Specifications.

1.4 QUALITY ASSURANCE

A. Mock-Up:
   1. Provide full-scale mock-up under provisions of Section 01400. Construct at least two months before start of concrete work. Allow concrete to cure 28 days before observation.
   2. At location on Project selected by Owner’s Representative, demonstrate each forming and finishing condition required on Project using materials, workmanship, joint treatment, form ties, curing method, and patching techniques to be used throughout Project. Paving mock-ups shall be a minimum 4-foot x 4-foot for each type of finish.
   3. Accepted mock-up provides visual standard for work of Section.
   4. Mock-up may remain as part of Work

B. The GEOTECHNICAL ENGINEER will perform concrete compression tests and other quality control testing and inspection as indicated.

PART 2 - PRODUCTS

2.1 CONCRETE:

A. Concrete shall conform to the requirements for "Concrete Curbs and Sidewalks" as described in Section 73 of the State of California Department of Transportation Standard Specifications.

B. Concrete must contain at least 505 pounds of cementitious material per cubic yard.

C. Water to cement ratio shall be 0.50 or less.

2.2 REINFORCEMENT

A. ASTM A615, grade 40 for #3 and smaller bars and grade 60 for #4 and larger bars

2.3 PIGMENTS FOR INTEGRALLY COLORED CONCRETE

A. Manufacturer:
   1. Davis Colors manufactured by Davis Colors
   2. Colored additives shall contain pure, concentrated mineral pigments specially processed for mixing into concrete and complying with ASTM C979.
   3. Do not use calcium chloride admixtures with color additives.

B. Finished Concrete Color: Provide cement, sand, aggregate and color additive as required to match sample provided by ARCHITECT.

C. Colors:
   1. Paving Type "P2": 'Miami Buff' pigment dosage to be adjusted to match Rosen Center colored concrete standard

2.4 ACCESSORIES

A. Expansion Joint Material
   1. Premolded Joint Filler: ASTM D1751, non-extruding and bituminous type resilient filler, compatible with sealant and backer rod.
   2. Sealant Backer Rod:
      a. Type: Compressible polyethylene foam rod or other flexible, permanent, durable non-absorptive material as recommended by joint sealer manufacturer for compatibility with joint sealer.
      b. Product: "Sonofoam Backer-Rod" as manufactured by Sonneborn Building Products, (612) 835-3434or (415) 889-9899.

   3. Snap Cap: Seal tight Snap Cap by W.R. Meadows or similar.
   4. Joint Sealer
      a. Type: Multi-component polyurethane sealant, FS TT-S-00227, Class A, type as recommended by manufacturer for exterior locations subject to foot traffic.
      b. Product: ASTM C290, non-snag sealant "Dynatred" by Pecora Corporation, (214) 278-8158, or "Sonolastic Sealant NP1 & NP2" by Sonneborn, (612) 835-3434.
      c. Color: Submit Samples

   5. Bond Breaker: Polyethene tape as recommended by joint sealant manufacturer where bond to joint filler must be avoided for proper performance of joint sealer.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Concrete curbs: Construct in accordance with the Standard Specifications and as indicated on the Construction Drawings.

B. All concrete curbs must be completed and backfilled before asphalt concrete is placed.

C. Concrete installation and finish: Conform to the requirements of the Standard Specifications or as indicated on the Construction Drawings.

D. All exposed faces shall be finished. Faces in planter areas shall be finished to at least 6" below finish grade.

E. Saw Cut Joints
   1. Do not sawcut until seven (7) days after installation of slab.
   2. Cutting: Using accepted mechanical concrete saw. Employ only experienced personnel. Perform all cuts cleanly and smoothly, to a constant and equal depth. Perform in as continuous an operation as possible to avoid misalignment of joints. Use forms or templates as required to achieve consistent lines.
   3. Controls: Accurately align joints with all adjacent improvements.
   4. Protection: Protect all adjacent site improvements during construction of this work. Repair all damage to the satisfaction of the Landscape Architect and at no additional cost to Owner.

3.2 FINISHES

A. Concrete Paving Type "P2": Sand Blast Finish with integral color
   1. Locations: See Landscape Drawings and details for location.
   2. Schedule: Perform sand-blasting no sooner than 10 days after pouring each section of concrete
   3. Continuity: Perform in as continuous an operation as possible, utilizing the same work crew to maintain continuity of finish.
   4. Depth of Cut: Use an abrasive grit of the proper type and gradation to expose the aggregate and surrounding matrix surfaces to be approx. 1/16 in. depth. for light, approx. 1/8 in. to 3/16 in. depth. for medium, and approx. 3/16 in. to 1/4 depth. for heavy.
   5. Backup Boards: Blast corners and edge of patterns carefully, using backup boards in order to maintain a uniform corner or edge line.
   6. Uniformity: Use same nozzle, nozzle pressure and blasting technique as used for sample.
   7. Control: Maintain control of abrasive grit and concrete dust in each area of blasting.
   8. Clean Up: Remove all expended abrasive grit, concrete dust and debris at the end of each day of blasting operations.

END OF SECTION 321600

SECTION 32 14 13.19 - CONCRETE GRID PAVEMENTS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:
1. Concrete grid units.
2. Bedding sand.
3. Edge restraints.
4. Geotextiles.
5. Topsoil and grass for the grid openings.

1.2 REFERENCES

A. American Society of Testing Materials (ASTM)
1. C 33, Specification for Concrete Aggregates.
2. C 136, Method for Sieve Analysis for Fine and Coarse Aggregate.
3. C 140, Standard Test Methods of Sampling and Testing Concrete Masonry Units.
4. C 979, Standard Specification for Pigments for Integrally Colored Concrete.
5. C 1319, Standard Specification for Concrete Grid Paving Units.
6. D 698, Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,000 ft-lbf/ft^3 (600 kN-m/m^3)).
7. D 2940, Standard Specification for Graded Aggregate Material for Bases or Subbases for Highways or Airports.
8. D 5268, Specification for Topsoil Used for Landscaping Purposes.

B. Interlocking Concrete Pavement Institute (ICPI)
1. Tech Spec technical bulletins.

1.3 SUBMITTALS

A. In accordance with Conditions of the Contract and Division 1 Submittal Procedures Section.

B. Manufacturer's drawings and details: Indicate perimeter conditions, relationship to adjoining materials and assemblies, expansion and control joints, paving slab layout, patterns, arrangement, installation and setting details.

C. Sieve analysis per ASTM C 136 for grading of bedding and base materials.

D. Source and content of topsoil and grass seed.

E. Concrete grid units:
1. Color selected by Architect.
2. Four representative full-size samples of each grid type, thickness, color, finish that indicate the extremes of color variation and texture expected in the finished installation.
3. Accepted samples become the standard of acceptance for the work.
4. Test results from an independent testing laboratory for compliance of grid paving unit requirements to ASTM C 1319.
5. Manufacturer's certification of concrete grid units by ICPI as having met applicable ASTM standards.
6. Manufacturer's catalog literature, installation instructions, and material safety data sheets for the safe handling of the specified materials and products.

1.4 QUALITY ASSURANCE

A. Paving Subcontractor Qualifications:
1. Engage an experienced installer who has successfully completed grid pavement installations similar in design, material, and extent indicated for this Project.
2. Hold a current certificate from the Interlocking Concrete Pavement Institute Concrete Paver Installer Certification program.

B. Single-source Responsibility: Obtain each color, type, and variety of grids, joint materials and setting materials from single sources with resources to provide products and materials of consistent quality, appearance and physical properties without delaying progress of the Work.

C. Regulatory requirements and approvals: Work shall be subject to the review and approval of the project geotechnical engineer and County building official.

D. Mock-up
1. Locate where directed by the Architect.
2. Notify Architect in advance of dates when mock-ups will be erected.
3. Install minimum 100 sf of concrete grid units.
4. Use this area to determine the quality of workmanship in to be produced in the final unit of Work including surcharge of the bedding sand layer, joint sizes, lines, pavement laying pattern(s), color(s), and texture.
5. This area shall be used as the standard by which the work is judged.
6. Subject to acceptance by the owner, mock up may be retained as part of the finished work.
7. If mock up is not retained, remove and properly dispose of.

1.5 DELIVERY, STORAGE, AND HANDLING

A. General: Comply with Division 1 Product Requirement Section

B. Deliver concrete grid units to the site in steel banded, plastic banded, or plastic wrapped packaging capable of transfer by forklift or clamp lift. Unload grids at job site in such a manner that no damage occurs to the product or existing construction.

C. Cover sand with waterproof covering to prevent exposure to rainfall or removal by wind. Secure the covering in place.

D. Coordinate delivery and paving schedule to minimize interference with normal use of buildings adjacent to paving.

1.6 ENVIRONMENTAL CONDITIONS

A. Do not install bedding materials or grid units during heavy rain or snowfall.

B. Do not install bedding materials and grid units over frozen base materials.

C. Do not install frozen bedding materials.

PART 2 PRODUCTS

2.1 CONCRETE GRID UNITS

A. Manufacturer: Acker-Stone Industries - 13296 Temescal Canyon Road, Corona CA 92883
1. Contact: Angelica Wright 951-674-0047 ext 1313; or approved equal

B. Concrete grid units, including the following:
1. Grid unit type: Turf Block or approved equal
a. Size: 15 ½ inches x 23 ½ inches x 3.15 inches (8cm) thick.

C. Manufactured in a plant where paving products are certified by ICPI as having passed ASTM requirements in this specification.

2.2 PRODUCT SUBSTITUTIONS

A. Substitutions: As approved by the Owner.

2.3 BEDDING MATERIALS

A. General – Sieved per ASTM C 136.

B. Bedding Sand

1. Washed, clean, hard, durable crushed gravel or stone, free from shale, clay, friable materials, organic matter, frozen lumps, and other deleterious substances.
2. Conforming to the grading requirements in Table 1 below.

3. Do not use limestone screenings.

Table 1
ASTM C 33 Gradation for Bedding Sand

Sieve Size	Percent Passing
3/8 in. (9.5 mm)	100
No. 4 (4.75 mm)	95 to 100
No. 8 (2.36 mm)	85 to 100
No. 16 (1.18 mm)	50 to 85
No. 30 (0.600 mm)	25 to 60
No. 50 (0.300 mm)	10 to 30
No. 100 (0.150 mm)	2 to 10
No. 200 (0.075 mm)	0 to 1

2.4 FILL MATERIALS FOR GRID OPENINGS

A. Topsoil: Conform to ASTM D 5268.

B. Grass seed shall be either a red fescue (Festuca rubra) or bent grass (agrostis pallens) as approved by the Architect.

2.5 EDGE RESTRAINTS

A. Provide edge restraints installed around the perimeter of all concrete grid paving unit areas as follows:

1. Manufacturer: Curv-Rite, E-Z Edge or approved equal
2. Material: Aluminum, Steel, or Precast concrete, as approved by owner
3. Material standard: product shall be rated for industrial or heavy-duty application

PART 3 EXECUTION

3.1 EXAMINATION

A. Acceptance of site verification conditions:

1. Contractor shall inspect, accept and verify in writing to the grid installation subcontractor that site conditions meet specifications for the following items prior to installation of bedding materials and concrete grid units:
    a. Verify that drainage and subgrade preparation, compacted density and elevations conform to specified requirements.
    b. Verify that geotextiles, if applicable, have been placed according to drawing and specifications.
    c. Verify that base materials, thickness, compacted density, surface tolerances and elevations conform to specified requirements.
    d. Provide written density test results for the soil subgrade, base materials to the Owner, Contractor, and grid installation subcontractor.
2. Do not proceed with installation of bedding materials and concrete grids until subgrade soil and base conditions are corrected by the Contractor or designated subcontractor.

3.3 PREPARATION

A. Verify that subgrade and base is dry, certified by Contractor as meeting material, installation and grade specifications are ready to support sand, edge restraints, grids and imposed loads and in accordance with Section 310000 Earthwork.

B. Edge Restraint Preparation:

1. Install edge restraints per these specifications, drawings and manufacturer's recommendations.
2. Mount directly to finished base. Do not install on bedding sand.
3. The minimum distance from the outside edge of the base to the spikes shall be equal to the thickness of the base.

3.4 INSTALLATION

A. Spread the sand evenly over the compacted, dense-graded base course and screed uniformly to 1/2 to 1 in. (13 to 25 mm). Place sufficient sand to stay ahead of the laid grids.
B. Ensure the grid units are free from foreign materials before installation.
C. Lay the grid units on the bedding sand in the pattern(s) as approved by the Owner. Maintain straight joint lines.
D. Joints between the grids shall not exceed 3/16 in. (5 mm).
E. Fill gaps at the edges of the paved area with cut grids or edge units.
F. Cut grids to be placed along the edge with a double-bladed splitter or masonry saw.
G. Sweep top soil into the joints and openings until full.
H. Sweep the grid surface clear prior to compacting.
I. Compact and seat the grids into the screeded bedding sand using a low-amplitude, 75-90 Hz plate compactor capable of at least 4,000 lbs. (18 kN) centrifugal compaction force. Use rollers or a rubber or neoprene pad between the compactor and grids to prevent cracking or chipping. Do not compact within 6 ft (2 m) of the unrestrained edges of the grid units.
J. All work to within 6 ft (2 m) of the laying face must be left fully compacted at the completion of each day.
K. Broadcast grass seed at the rate recommended by seed source. Add topsoil to the surface to cover the seeds.
L. Remove excess topsoil on surface when the job is complete.
M. Water entire area. Do not allow traffic on pavement for 30 days; if seeded.

3.5 FIELD QUALITY CONTROL

A. After removal of excess top soil/aggregate, check final elevations for conformance to the drawings. Allow 1/8 to 1/4 in. (3 to 6 mm) above specified surface elevations to compensate for minor settlement.
B. The final surface tolerance from grade elevations shall not deviate more than ±3/8 in. (10 mm) over a 10 ft (3 m) straightedge.
C. The surface elevation of grid units shall be 1/8 to 1/4 in. (3 to 6 mm) above adjacent drainage inlets, concrete collars or channels.
D. Lippage: No greater than 1/8 in. (3 mm) difference in height between adjacent grid units.

3.6 PROTECTION

A. After work in the section is complete, the Contractor shall be responsible for protecting work from damage due to subsequent construction activity on the site.

END OF SECTION

SECTION 32 3113.53 - HIGH-SECURITY ANTI-CLIMB FENCES AND GATES

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. Drawings and Conditions of Contract, including General and Supplementary Conditions and Division 1 Administration Sections, apply to this Division.

1.2 SUMMARY

A. This Section includes the following:
   1. High-security Anti-Climb Fences and Gates
   2. Gates:
      a. Motor-operated, horizontal slide.
      b. Manual swing.
   3. Privacy fabric.

B. Related Sections include the following:
   1. Division 013513.16 Section "Special Project Procedures for Detention Facilities" for general requirements of detention work, including responsibilities of a single-source detention specialist.
   2. Division 033000 Section "Cast-in-Place Concrete" for concrete bases/pads for gate operators, and controls, post concrete fill and continuous concrete mow strip.
   3. Division 087163 Section "Detention Door Hardware" for detention locks for swing and slide gates.
   4. Division 260500 Sections for Basic Electrical Materials and Methods.
   5. Division 312000 Section "Earth Moving" for excavation, filling, and grading work.

1.3 PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide anti-climb fences and gates capable of withstanding the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
   1. Line Post Design: Provide line posts of size and in spacing indicated but not less than sizes and spacings required to comply with CLFMI WLG 2445 in resisting the following wind-load criteria, based on fence height, mesh size, and pattern indicated:
      a. Design Wind Loads: Determine design wind loads applicable to Project from basic wind speed and exposure category indicated below and according to CLFMI WLG 2445:
         1) Wind Speed: 85mph.
         2) Exposure Category: C.
      b. Fence Height: As indicated on Drawings.
      c. Fence Framework Material Group: IA, ASTM F 1043, Schedule 40 steel pipe or IC, electric-resistance-welded round steel pipe.

B. Grounding Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

1.4 SUBMITTALS

A. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for anti-climb fences and gates:
   1. Fence and gate posts, rails, and fittings.
   2. Anti-Climb fabric, reinforcements, and attachments.
   3. Gates and hardware.
   4. Accessories: Barbed wire.

B. Shop Drawings: Show locations of fences, gates, posts, rails, tension wires, details of extended posts, extension arms, gate swing, or other operation, hardware, and accessories. Indicate materials, dimensions, sizes, weights, and finishes of components. Include plans, gate elevations, sections, details of post anchorage, attachment, bracing, and other required installation and operational clearances.
   1. Wiring Diagrams: Power and control wiring and communication access-control features.
   2. For installed products indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Product Certificates: For each type of fence, operator, and gate, signed by product manufacturer.
   1. Strength test results for framing according to ASTM F 1043.

D. Qualification Data: For Installer and testing agency.

E. Field quality-control test reports: Test results for compliance of fence and gate grounding and bonding with performance requirements.

F. Soil sterilization certificate of treatment stating materials and quantities used, and date of application.

G. Maintenance Data: For the following to include in maintenance manuals:
   1. Polymer finishes.
   2. Gate operator.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has completed anti-climb fences and gates similar in material, design, and extent to those indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
   1. Superintendent in Charge of installation to have minimum of five (5) years experience in installation of high security anti-climb fences.
   2. Engineering Responsibility: Preparation of data for anti-climb fences and gates, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.

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 according to NETA ETT or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 2008 edition, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. UL Standard: Provide gate operators that comply with UL 325.

E. Mockups: Build mockups to set quality standards for fabrication and installation.
   1. Include 30-ft. (9-m) length of fence and gate complying with requirements.
      a. Approval of mockups is also for other material and construction qualities specifically approved by Architect in writing.
      b. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups, unless such deviations are specifically approved by Architect in writing.
   2. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

F. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 013100 Section "Project Management and Coordination."

1.6 PROJECT CONDITIONS

A. Field Measurements: Verify layout information for anti-climb fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

1.7 COORDINATION

A. Coordinate, schedule, and obtain Owner's written approval of interruptions to existing perimeter security fences and systems for installation of new Work.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer and Installer agrees to repair or replace components of high-security anti-climb fences and gates that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
      b. Deflection of fence fabric beyond design limits.
   2. Warranty Period (overall system): Five years from date of Substantial Completion.

3. Warranty for Fencing Fabric: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Gate Operator:
1. Basis-of-Design Product: Subject to compliance with requirements, provide HySecurity; 40-C with 1010 series deadlock cover or a comparable product by one of the following:
a. Eagle Access Control Systems, Inc.
b. Tymetal Corp.

2.2 TENSION WIRE

A. General: Provide horizontal tension wire at the following locations:
1. Location: Extended along top of fence fabric.

B. Metallic-Coated Steel Wire: 0.177-inch- (4.5-mm-) diameter, marcelled tension wire complying with ASTM A 824 and the following:
1. Metallic Coating: Type II, zinc coated (galvanized) by hot-dip process, with the following minimum coating weight:
a. Class 3: Not less than 2.0 oz./sq. ft. (610 g/sq. m) of uncoated wire surface.

2.3 WELDED WIRE FABRIC

A. Anti-Climb Fence Fabric: Height indicated on Drawings. Provide fabric in one-piece panels measured between top and bottom of fence. Comply with ASTM A185/A185M, and with requirements indicated below:
1. Steel Wire Fabric: Metallic/PVC Color coated.
a. Wire Diameter: 8 gauge
b. Mesh Size: 1/2 inch x 3 inch
c. Weight of Metallic (Zinc) Coating: ASTM A641/A641M, Type II, Class 1, 1.2 oz/sq. ft. (366 g/sq. m) with zinc coating applied after fabrication.
d. Coating: Minimum 4 mil polyester coating.
e. Color: Manufacturer’s standard colors as selected by the Architect.
f. Wire breaking load: minimum 80,000 PSI
g. Weld Shears strength: Minimum 1,050 pounds
h. Manufacturers:
1) Designmaster Fencing System; DMF Forte Max Security)Basis-of-Design).
2) BetaFence
3) Riverdale Mills.

2.4 SECURITY FENCE FRAMING

A. Posts and Rails: Comply with ASTM F 1043 for framing of the following material group and strength requirement for fences of height indicated:
   1. Framework Material Group: IA, round steel pipe, Schedule 40 or IC, round steel pipe with a yield strength of 50,000 psi (345 MPa).
   2. Fence Height: As indicated on Drawings.
   3. Strength Requirement: Heavy industrial fence.
   4. Post Diameter and Thickness: Provide posts of sizes indicated below that comply with ASTM F 1043 or ASTM F 1083.
      a. Line Post: Minimum 2.875-inch (73-mm) diameter, 0.203-inch (5.2-mm) thickness round pipes.
      b. End, Corner, and Pull Post: Minimum 4-inch (102-mm) diameter, 0.237-inch (6.02-mm) thickness.
      c. Single Gates to 4 ft. (1.2 m) wide: 4 x 4 x ¼" (100 x 100 x 6 mm) steel tube, ASTM A500, Grade B.
      d. Double Wide Gates for openings up to 16 ft. (4.8 m) wide: 6" x 6" x ¼" (150 x 150 x 6 mm) steel tube, ASTM A500, Grade B.
      e. Horizontal-Slide Gate Post:
         1) Openings up to 16 Feet (3 m), Overhead Clearance up to 14 Feet (4.27 m): 6" x 6" x ¼" (150 x 150 x 6 mm) galvanized steel tube, ASTM A 500 with minimum 2.3 oz. (62.2 g) ZMC coating per square foot per ASTM A123 (A123M).
         2) Openings up to 24 Feet (7.3 m), Overhead Clearance up to 22 Feet (6.7 m): Steel post, 8.625-inch (219-mm) diameter, and 27.12-lb/ft. (40.36-kg/m) weight.
   5. Metallic Coatings for Steel Framing:
      a. Type A, consisting of not less than minimum 2.0-oz./sq. ft. (0.61-kg/sq. m) average zinc coating per ASTM A 123.
      b. Coatings: Minimum 4 mil polyester coating.
      c. Color: Manufacturer's standard colors as selected by the Architect.

2.5 SWING GATES

A. General: Comply with ASTM F 900 for single and double swing gate types.
   1. Metal Tubing: Galvanized steel. Comply with ASTM F 1043 and ASTM F 1083 for materials and protective coatings.

B. Frames and Bracing: Fabricate members from rectangular, galvanized steel tubing with outside dimension and weight according to ASTM F 900 and the following:
   1. Gate Fabric Height: As indicated on Drawings.
   2. Leaf Width: As indicated on Drawings.
   3. Frame Members:
      a. Tubing Size: Minimum 2 inches (51 mm) rectangular.

C. Frame Corner Construction:
   1. Welded with and 3/8-inch- (9.5-mm-) diameter, adjustable truss rods for panels 5 feet (1.52 m) wide or wider.

D. Extended Gate Posts and Frame Members: Extend gate posts and frame end members above top of anti-climb fabric at both ends of gate frame as indicated and as required to attach barbed wire assemblies.

E. Provide separate isolated gate frame according to ASTM F 1916 and as indicated.
1. Group: IA, round steel pipe, Schedule 40 or IC, round steel pipe, yield strength 50,000 psi (345 MPa).
2. Post: 4 inches (102 mm).
3. Separation between Hinge and Latch Post and Fence Termination Post: 2 inches (51 mm) minimum, 2-1/2 inches (63.5 mm) maximum.

F. Hardware:
1. Hinges: For swing gates up to 7 feet (2.1 m) high and 4 feet (1.2 m) wide, 5 inch heavy duty security weld on hinges. For gates over 7 feet (2.1 m) high and 4 feet (1.2 m) wide, weld on barrel or square block hinges with mild steel bodies, stainless steel non-removable pins, ball bearing and grease fitting.
2. Latches permitting operation from both sides of gate. Fabricate latches with integral eye openings for padlocking; padlock accessible from both sides of gate.
3. For swing gates indicated to have detention locks, refer to Division 8 Section “Detention Door Hardware” for lock type.

2.6 HORIZONTAL-SLIDE GATES

A. General: Comply with ASTM F 1184 for single slide gate types for materials and protective coatings:
1. Classification: Type I Overhead Slide.
a. Gate Leaf Width: As indicated.
b. Framework Member Sizes and Strength: Based on gate fabric height of more than 72 inches.

B. Frames and Bracing: Fabricate members from square, galvanized steel tubing with outside dimension and weight according to ASTM F 1184 and the following:
1. Gate Fabric Height: As indicated on drawings.
2. Gate Opening Width: As indicated on drawings.
3. Frame Members:
a. Tubing Size: Minimum 2 inches (51 mm) square.
4. Bracing Members:
a. Tubing Size: Minimum 2 inches (51 mm) square.

C. Frame Corner Construction:
1. Welded frame with 5/16-inch- (7.9-mm-) diameter, adjustable truss rods for panels 5 feet (1.52 m) wide or wider.

D. Extended Gate Posts and Frame Members: Extend gate posts and frame end members above top of chain-link fabric at both ends of gate frame as indicated and as required to attach barbed wire assemblies.

E. Overhead Track Assembly: Manufacturer's standard track, with overhead framing supports, bracing, and accessories, engineered to support size, weight, width, operation, and design of gate and roller assemblies.

F. Roller Guards: As required per ASTM F 1184 for Type II, Class 1 gates.

G. Hardware:
1. Lock: Manufacturer's standard internal device furnished in lieu of gate latch.
2. Hangers, roller assemblies, and stops fabricated from galvanized steel, galvanized malleable iron or mill-finished Grade 319 aluminum-alloy casting with stainless-steel fasteners.
3. Gate Guide Angle: Galvanized steel angle, minimum 2-1/2 inch x 1-1/2 inch x ¼ inch (63 x 38 x 6 mm) thick, full length of gate, welded to bottom of gate frame.
4. Bottom Guide: Nominal S3 x 5.7 galvanized steel beam with welded on galvanized steel guides. Beam length to be equal to gate travel.
   a. Steel Guides: Nominal 3/8 inch thick x 12 inches (9.5 mm x 305 mm) long with beveled ends.

2.7 FITTINGS

A. General: Comply with ASTM F 626.

B. Post and Line Caps: Each post.

C. Rail and Brace Ends: Attach rails securely to each gate, corner, pull, and end post.

D. Rail Fittings: Provide the following:
1. Top-Rail Sleeves: Pressed steel or round steel tubing not less than 6 inches (152 mm) long.
2. Rail Clamps: Line and corner boulevard clamps for connecting intermediate and bottom rails in the fence line to line posts.

E. Tension and Brace Bands: Pressed steel, 0.105 inch (2.66 mm) thick, with 1.2-oz/sq. ft. (366-g/sq. m) metallic (zinc) coating.

F. Truss Rod Assemblies: Steel, hot-dip galvanized after threading rod and turnbuckle or other means of adjustment.

G. Barbed Wire Arms: Pressed steel or cast iron, with clips, slots, or other means for attaching strands of barbed wire, integral with post cap; for each post, unless otherwise indicated, and as follows:
1. Line posts with arms designed with opening to accommodate tension wire.
2. Corner arms at fence corner posts, unless extended posts are indicated.
3. Type I, single slanted arm.
4. Tack welded or riveted for connection to post.

H. Clips, and Fasteners: According to ASTM F 626 and ASTM F 1916.
1. Metallic-Coated Steel: Minimum 0.148-inch- (3.76-mm-) diameter wire; galvanized coating thickness matching coating thickness of anti-climb fence fabric.

I. Power-Driven Fabric Fasteners: As indicated on Drawings.

J. Screw Fabric Fasteners: As indicated on Drawings.

K. Finish:
1. Metallic Coating for Pressed Steel or Cast Iron: Not less than 1.2 oz. /sq. ft. (366 g /sq. m) of zinc.

2.8 BARBED WIRE

A. Zinc-Coated Steel Barbed Wire: Comply with ASTM A 121, Anti-climb Fence grade for the following 2-strand barbed wire:
1. Standard Size and Construction: 0.099-inch- (2.51-mm-) diameter line wire with 0.080-inch- (2.03-mm-) diameter, 4-point round barbs spaced not more than 5 inches (127 mm) o.c.

2.9 PRIVACY FABRIC

A. Basis-of-Design Product: Subject to compliance with requirements, provide FenceScreen, Inc.; 600 Series Professional Knitted Open Mesh Windscreen.
1. Similar products by other manufacturers will be reviewed in accordance with Substitution Procedures as identified in project general conditions.

B. Open Mesh Polypropylene Fabric: Provide open mesh polypropylene fencing fabric complying with the following minimum physical characteristics:
1. Weight: 4.9 oz/yd³ (ASTM D 5261).
2. Warp Tensile Strength: 75 lbs. (ASTM D 5100).
3. Wear Tear Resistance: 120 lbs. (ASTM D 2261).
4. Fill Tensile Strength: 180 lbs. (ASTM D 5100).
5. Fill Tear Resistance: 320 lbs. (ASTM D 5512).
6. Air Flow: 22% (ASTM D 737).
7. Melting Temperature: 335°F.
8. Shade Percentage: 78%.
9. UV Stable, including color change for duration of warranty period.
10. Color: As selected by Architect from manufacturer's full range of colors.
11. Mounting Accessories: Brass grommets with reinforced edge binding.

2.10 GATE OPERATORS

A. General: Provide factory-assembled automatic operating system designed for gate size, type, weight, and operation frequency. Provide operation control system with characteristics suitable for Project conditions, with remote-control stations, safety devices, and weatherproof enclosures; coordinate electrical requirements with building electrical system.
1. Provide operator designed so motor may be removed without disturbing limit-switch adjustment and without affecting auxiliary emergency operator.
2. Provide operator with UL approval and/or approved components.
3. Provide electronic components with built-in troubleshooting diagnostic feature.
4. Provide unit designed and wired for both right-hand/left-hand opening, permitting universal installation.

B. Comply with NFPA 70.

C. Motor Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, within installed environment, with indicated operating sequence, and without exceeding nameplate rating or considering service factor. Comply with NEMA MG 1, and the following:
   1. Voltage: 480 V.
   2. Horsepower: 3/4.
   3. Enclosure: Open drip proof.
   4. Duty: Continuous duty at ambient temperature of 105 deg F (40 deg C) and at altitude of 3300 feet (1005 m) above sea level.
   5. Service Factor: 1.15 for open drip proof motors.
   6. Phase: Polyphase.

D. Gate Operators: Concrete base/pad or Pedestal post mounted and as follows:
   1. Hydraulic Slide Gate Operators:
      a. Duty: Heavy.
      b. Gate Speed: Minimum 45 feet (13.7 m) per minute.
      c. Maximum Gate Weight: 2000 lb (900 kg).
      d. Frequency of Use: Continuous duty.
      e. Operating Type: Wheel and rail drive with manual release.
      f. Hydraulic Fluid: Of viscosity required for gate operation at ambient temperature range for Project.
      g. Locking: Hydraulic in both directions.
      h. Heater: Manufacturer's standard track and roller heater with thermostatic control.

E. Remote Controls: Electric controls tied into security electronics in Central Control.

F. Limit Switches: Adjustable switches, interlocked with motor controls and set to automatically stop gate at fully retracted and fully extended positions.

G. Vehicle Loop Detector: System that includes automatic closing timer with adjustable time delay before closing, timer cut-off switch, and loop detector designed to open and close gate at exit gate only. Provide electronic detector with adjustable detection patterns, adjustable sensitivity and frequency settings, and panel indicator light designed to detect presence or transit of a vehicle over an embedded loop of wire and to emit a signal activating the gate operator. Provide number of loops consisting of multiple strands of wire, number of turns, loop size, and method of placement at location shown on Drawings, and as recommended in writing by detection system manufacturer for function indicated.
   1. Loop: Field-assembled wire, in size indicated, for pave-over installation.

H. Emergency Release Mechanism: Quick-disconnect release of operator drive system of the following type of mechanism, permitting manual operation if operator fails. Design system so control circuit power is disconnected during manual operation.
   1. Type: Mechanical device, key, or crank-activated release.

I. Operating Features:
   1. Digital Microprocessor Control: Electronic programmable means for setting, changing, and adjusting control features with capability of monitoring and auditing gate activity. Provide unit that is isolated from voltage spikes and surges.
   2. System Integration: With controlling circuit board capable of accepting any type of input from external devices.
   3. Open Override Circuit: Designed to override closing commands.

4. Reversal Time Delay: Designed to protect gate system from shock load on reversal in both directions.
5. Maximum Run Timer: Designed to prevent damage to gate system by shutting down system if normal time to open gate is exceeded.

2.11 GROUT AND ANCHORING CEMENT

A. Non-shrink, Nonmetallic Grout: Premixed, factory-packaged, non-staining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout, recommended in writing by manufacturer, for exterior applications.

B. Erosion-Resistant Anchoring Cement: Factory-packaged, non-shrink, non-staining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating and that is recommended in writing by manufacturer for exterior applications.

2.12 FENCE GROUNDING

A. Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.
1. Material above Finished Grade: Copper or Aluminum.
2. Material on or below Finished Grade: Copper.
3. Bonding Jumpers: Braided copper tape, 1 inch (25.4 mm) wide, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.

B. Connectors and Grounding Rods: Listed in UL 467.
1. Connectors for Below-Grade Use: Exothermic welded type.
2. Grounding Rods: Copper-clad steel.
a. Size: 5/8 by 96 inches (16 by 2400 mm).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for site clearing, earthwork, pavement work, and other conditions affecting performance.
1. Do not begin installation before final grading is completed, unless otherwise permitted by Architect.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet (152 m) or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments, communication lines, etc.

3.3 INSTALLATION, GENERAL

A. Install anti-climb fencing to comply with ASTM F 567 and more stringent requirements specified.
   1. Install fencing on established boundary lines inside property line.

3.4 ANTI-CLIMB FENCE INSTALLATION

A. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.

B. Post Setting: Set posts in concrete or into soil as shown on Drawings at indicated spacing into firm, undisturbed soil.
   1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
   2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
      a. Exposed Concrete: Extend 2 inches (51 mm) above grade; shape and smooth to shed water.
      b. Concealed Concrete: Top even with bottom of concrete mow strip to allow covering with concrete mow strip.
      c. Posts Set into Concrete in Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions, and finished sloped to drain water away from post.
      d. Posts Set into Voids in Concrete Slabs: Form or core drill holes not less than 3/4 inch (19 mm) larger than OD of post. Extend hole to depth indicated. Clean holes of loose material, set posts in concrete, and fill annular space between post and concrete slab with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions, and finished sloped to drain water away from post.
   3. Temporary Fence Posts: Place posts in holes to a minimum depth of 36 inches (914 mm). Place granular fill around posts to hold them in place.

C. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more.

D. Line Posts: Space line posts uniformly at maximum width dimension of 8 feet to accommodate anti-climb fabric widths.

E. Post Bracing and Intermediate Rails: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Install braces at end and gate posts and at both sides of corner and pull posts.
   1. Locate horizontal braces at midheight of fabric 6 feet (1.8 m) or higher, on fences with top rail and at 2/3 fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.

F. Barbed Wire Arms: Tack weld or rivet to top of post. Angle single arms toward inmate approach side of fence unless indicated otherwise.

G. Tension Wire: Install according to ASTM F 567 and ASTM F 1916, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch- (3.05-mm-) diameter hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches (610 mm) o.c. Install tension wire in locations indicated before stretching fabric.
1. At Contractors option, tension wire may be threaded through fence fabric in lieu of using hog rings.

H. Bottom Rails: Install, spanning between posts.

I. Anti-Climb Fabric: Apply fabric to facility side of framework. Pull fabric taut and tie to posts and rails.
1. Leave 1 inch (25.4 mm) between finish grade or surface and bottom selvage, unless otherwise indicated.
2. Overlapping Fabric: At or between post or rail according to ASTM F 1916 with wire ties or steel strap method.

J. Power-Driven or Screw Fasteners: Fasten fabric to posts and rails as indicated on Drawings.

K. Fasteners: Install nuts for tension bands and carriage bolts on the side of fence opposite the fabric side. Peen ends of bolts, tack weld or score threads to prevent removal of nuts.

L. Barbed Wire: Install barbed wire uniformly spaced as indicated on Drawings. Pull wire taut and install securely to extension arms and secure to end post or terminal arms. Where indicated, install barbed wire through loop in post cap.

M. Grounding Barrier Stakes: Stake ground coils at 10 feet (3 m) o.c., driven to full depth.

N. Install privacy fabric to fencing at site perimeter fencing and where indicated on Drawings. Attach fabric to fencing per manufacturer’s written instructions.

3.5 GATE INSTALLATION

A. Install gates according to manufacturer's written instructions and approved Shop Drawings. Install level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

3.6 GROUNDING AND BONDING

A. Fence Grounding: Install at maximum intervals of 500 feet (152 m) and except as follows:
1. Gates and Other Fence Openings: Ground fence on each side of opening for double gates and vehicle slide gates, one side of fence on swing and pedestrian slide gates.

B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet (45 m) on each side of crossing.

C. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches (152 mm) below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location:

D. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
   1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
   2. Make connections with clean, bare metal at points of contact.
   3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
   4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
   5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.7 FIELD QUALITY CONTROL

A. Grounding-Resistance Testing: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.
   1. Grounding-Resistance Tests: Subject completed grounding system to a megger test at each grounding location. Measure grounding resistance not less than two full days after last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural grounding resistance. Perform tests by two-point method according to IEEE 81.
   2. Excessive Grounding Resistance: If resistance to grounding exceeds specified value, notify Architect promptly. Include recommendations for reducing grounding resistance and a proposal to accomplish recommended work.
   3. Report: Prepare test reports, certified by testing agency, of grounding resistance at each test location. Include observations of weather and other phenomena that may affect test results.

3.8 ADJUSTING

A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

B. Lubricate hardware and other moving parts.

END OF SECTION 32 3113.53

SECTION 323119 - DECORATIVE METAL FENCES AND GATES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Decorative steel fences.
   2. Swing gates.
   3. Horizontal-slide gates.
   4. Gate operators, including controls.

B. Related Requirements:
   1. Section 033000 "Miscellaneous Cast-in-Place Concrete" for concrete post concrete fill.
   2. Section 281300 "Access Control" for access control devices installed at gates and provided as part of a security system.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For gates. Include plans, elevations, sections, details, and attachments to other work.
   1. Include diagrams for power, signal, and control wiring.

C. Samples: For each fence material and for each color specified.
   1. Provide Samples 12 inches (300 mm) in length for linear materials.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Product Test Reports: For decorative metallic-coated-steel tubular picket fences, including finish, indicating compliance with referenced standard and other specified requirements.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For gate operators to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of products.

B. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for fabrication and installation.
   1. Include 10-foot (3-m) length of fence complying with requirements.
   2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Lightning-Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

2.2 DECORATIVE STEEL FENCES

A. Decorative Steel Fences: Fences made from steel tubing bars and shapes.
   1. Designmaster Fencing System; Contempo Fence System (Basis of Design).
   2. Ameristar Wireworks, Inc.
   3. Ametco Manufacturing Corp.
   4. Metallico Fence and Railing Screen and Gate Systems

B. Posts: Square steel tubing.
   1. Galvanized steel tube, ASTM A513/A787, G60 coating class, 2 x 2 inches, 16 gauge.
   2. Length: To suit panel height and post mounting method.

C. Post Caps: Formed from steel sheet

D. Post Brackets;
   1. Galvanized steel and powder coated, sized to post dimensions, with a 1 ¼ inch galvanized nut and bolt.

E. Fence Panels:
   1. Resistance welded steel wire mesh, ASTM A185/A185M, 6 gauge Class 1 Galvanized steel wire per ASTM A641/A641M, 2x6 inch mesh, stiffened with horizontal V-shaped braces.
   2. Height; 8 feet
   3. Wire breaking load; Minimum 80,000 psi.
   4. Weld shears strength: Minimum 1,050 pounds.

F. Accessories
   1. Concrete: ASTM C94; Specified in Section 033000; minimum 2500 psi compressive strength at 28 days, 3 to 5 inch slump.

G. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A 123/A 123M. For hardware items, hot-dip galvanize to comply with ASTM A 153/A 153M.
   1. Hot-dip galvanize components, posts and panels.

H. Finish components, posts and panels: Powder coating.

2.3 SWING GATES

A. Gate Configuration: Single leaf and Double leaf.

B. Gate Frame Height: 96 inches.

C. Gate Opening Width: 36 inches for man gates and 192 inches for double leaf vehicle gates

D. Framing: Steel tube, same construction and finish as posts, welded 45 degree corners and intersections, sized to gate dimensions.

E. Hinges: Heavy duty industrial type, adjustable.

F. Hardware: Latches permitting operation from both sides of gate, hinges, and keepers for each gate leaf more than 5 feet (1.52 m) wide. Provide center gate stops and cane bolts for pairs of gates. Fabricate latches with integral eye openings for padlocking; padlock accessible from both sides of gate.

G. Spring Hinges: BHMA A156.17, Grade 1, suitable for exterior use.
   1. Location: Visitation patio gates.
   2. Function: 320 - Gate spring pivot hinge. Adjustable tension
   3. Material: Malleable iron; galvanized.

2.4 HORIZONTAL-SLIDE GATES

A. Gate Configuration: As indicated.
   1. Type: Ground (Vee)-track.

B. Gate Frame Height: As indicated.

C. Gate Opening Width: As indicated.

D. Automated vehicular gates shall comply with ASTM F 2200, Class IV.

E. Galvanized-Steel Frames and Bracing: Fabricate members from square tubing.
   1. Frame Members: In shapes as indicated on Drawings, formed from members as required, but not less than 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or

formed from not less than 0.105-inch (2.66-mm) nominal-thickness steel sheet and hot-dip galvanized after fabrication.

2. Bracing Members: In shapes as indicated on Drawings formed from not less than 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or formed from not less than 0.105-inch (2.66-mm) nominal-thickness steel sheet and hot-dip galvanized after fabrication.

F. Frame Corner Construction:
1. Welded frame with panels assembled with bolted or riveted corner fittings and 5/16-inch-(7.9-mm-) diameter, adjustable truss rods for panels 5 feet (1.52 m) wide or wider.
2. Overhead Slide Gates: Welded or assembled with corner fittings including 5/16-inch-(7.9-mm-) diameter, adjustable truss rods for panels 5 feet (1.52 m) wide or wider.

G. Additional Rails: Provide as indicated, complying with requirements for fence rails.

H. Infill: Comply with requirements for adjacent fence.

I. Overhead Track Assembly: Manufacturer's standard track, with overhead framing supports, bracing, and accessories, engineered to support size, weight, width, operation, and design of gate and roller assemblies.

J. Hardware:
1. Lock: Manufacturer's standard internal device furnished in lieu of gate latch.
2. Hangers, roller assemblies, and stops fabricated from galvanized steel, galvanized malleable iron or mill-finished Grade 319 aluminum-alloy casting with stainless-steel fasteners.
3. Gate Guide Angle: Galvanized steel angle, minimum 2-1/2 inch x 1-1/2 inch x ¼ inch (63 x 38 x 6 mm) thick, full length of gate, welded to bottom of gate frame.
4. Bottom Guide: Nominal S3 x 5.7 galvanized steel beam with welded on galvanized steel guides. Beam length to be equal to gate travel.
   a. Steel Guides: Nominal 3/8 inch thick x 12 inches (9.5 mm x 305 mm) long with beveled ends.

K. Finish exposed welds to comply with NOMMA Guideline 1, Finish #3 - partially dressed weld with splatter removed.

L. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A 123/A 123M. For hardware items, hot-dip galvanize to comply with ASTM A 153/A 153M.

M. Metallic-Coated-Steel Finish: Galvanized finish.

N. Steel Finish: High-performance coating.

2.5 GATE OPERATORS

A. Gate Operators:
1. Basis-of-Design Product: Subject to compliance with requirements, provide HySecurity; 50 V/F 2-3-C with 1010 series deadlock cover or a comparable product by one of the following:

a. Eagle Access Control Systems, Inc.
b. Tymetal Corp.

B. Provide factory-assembled automatic operating system designed for gate size, type, weight, and operation frequency. Provide operation control system with characteristics suitable for Project conditions, with remote-control stations, safety devices, and weatherproof enclosures; coordinate electrical requirements with building electrical system.
1. Provide operator designed so motor may be removed without disturbing limit-switch adjustment and without affecting auxiliary emergency operator.
2. Provide operator with UL approval.
3. Provide electronic components with built-in troubleshooting diagnostic feature.
4. Provide unit designed and wired for both right-hand/left-hand opening, permitting universal installation.

C. Comply with NFPA 70.

D. UL Standard: Manufacturer and label gate operators to comply with UL 325.

E. Emergency Access Requirements: Comply with requirements of authorities having jurisdiction for automatic gate operators on gates that must provide emergency access.

F. Motor Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, within installed environment, with indicated operating sequence, and without exceeding nameplate rating or considering service factor. Comply with NEMA MG 1 and the following:
1. Voltage: 120 V.
2. Horsepower: As required for operation of gate.
3. Enclosure: Totally enclosed.
4. Duty: Continuous duty at ambient temperature of 105 deg F (40 deg C) and at altitude of 3300 feet (1005 m) above sea level.
5. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.
6. Phase: One.

G. Gate Operators: Concrete base/pad or Pedestal post mounted and as follows:
1. Hydraulic Slide Gate Operators:
a. Duty: Heavy.
b. Gate Speed: Variable 2-3 feet per second.
c. Maximum Gate Weight: 5000 lb (900 kg).
d. Frequency of Use: Continuous duty.
e. Operating Type: Wheel and rail drive with manual release.
f. Hydraulic Fluid: Of viscosity required for gate operation at ambient temperature range for Project.
g. Locking: Hydraulic in both directions.
h. Heater: Manufacturer's standard track and roller heater with thermostatic control.

H. Remote Controls: Electric controls separated from gate and motor and drive mechanism, with NEMA ICS 6, Type 4 enclosure for mounting as indicated on Drawings, and with space for additional optional equipment. Provide the following remote-control device(s):

1. For gates as indicated on Detail 26/A1.0.2: Electric controls tied into security electronics in Central Control with intercom functionality as indicated on Special Systems / Security Electronics Drawings.

2. For gates as indicated on Detail 55/A1.0.2: Functions only when authorized card is presented.
    a. Reader Type: Refer to Special Systems / Security Electronics Drawings and Division 28.

A. Vehicle Loop Detector: System that includes automatic closing timer with adjustable time delay before closing, timer cut-off switch, and loop detector designed to open and close gate at exit gate only. Provide electronic detector with adjustable detection patterns, adjustable sensitivity and frequency settings, and panel indicator light designed to detect presence or transit of a vehicle over an embedded loop of wire and to emit a signal activating the gate operator. Provide number of loops consisting of multiple strands of wire, number of turns, loop size, and method of placement at location shown on Drawings, and as recommended in writing by detection system manufacturer for function indicated.
    1. Loop: Field-assembled wire, in size indicated, for pave-over installation.

B. Obstruction Detection Devices: Provide each motorized gate with automatic safety sensor(s). Activation of sensor(s) causes operator to immediately function as follows:
    1. Action: Reverse gate in both opening and closing cycles, and hold until clear of obstruction.
    2. Action: Stop gate in opening cycle and reverse gate in closing cycle, and hold until clear of obstruction.
    3. Internal Sensor: Built-in torque or current monitor senses gate is obstructed.
    4. Sensor Edge: Contact-pressure-sensitive safety edge, profile, and sensitivity designed for type of gate and component indicated, in locations as follows. Connect to control circuit using gate edge transmitter and operator receiver system.
        a. Along entire gate leaf leading edge.
        b. Along entire gate leaf trailing edge.

C. Limit Switches: Adjustable switches, interlocked with motor controls and set to automatically stop gate at fully retracted and fully extended positions.

D. Emergency Release Mechanism: Quick-disconnect release of operator drive system of the following type, permitting manual operation if operator fails. Design system so control-circuit power is disconnected during manual operation.
    1. Type: Mechanical device, key, or crank-activated release.

E. Operating Features:
    1. Digital Microprocessor Control: Electronic programmable means for setting, changing, and adjusting control features with capability for monitoring and auditing gate activity. Provide unit that is isolated from voltage spikes and surges.
    2. System Integration: With controlling circuit board capable of accepting any type of input from external devices.
    3. Master/Slave Capability: Control stations designed and wired for gate pair operation.
    4. Automatic Closing Timer: With adjustable time delay before closing and timer cutoff switch.
    5. Open Override Circuit: Designed to override closing commands.
    6. Reversal Time Delay: Designed to protect gate system from shock load on reversal in both directions.
    7. Maximum Run Timer: Designed to prevent damage to gate system by shutting down system if normal time to open gate is exceeded.

F. Accessories:
1. Fire box.
2. Instructional, Safety, and Warning Labels and Signs: According to UL 325.
3. Equipment Bases/Pads: Precast concrete, depth not less than 12 inches, dimensioned and reinforced according to gate operator component manufacturer's written instructions and as indicated on Drawings.

2.6 MISCELLANEOUS MATERIALS

A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

B. Nonshrink Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107/C 1107M and specifically recommended by manufacturer for exterior applications.

2.7 GROUNDING MATERIALS

A. Grounding Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.
1. Material above Finished Grade: Copper.
2. Material on or below Finished Grade: Copper.
3. Bonding Jumpers: Braided copper tape, 1 inch (25 mm) wide, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.

B. Grounding Connectors and Grounding Rods: Comply with UL 467.
1. Connectors for Below-Grade Use: Exothermic-welded type.
2. Grounding Rods: Copper-clad steel.
a. Size: 5/8 by 96 inches (16 by 2440 mm).

2.8 METALLIC-COATED-STEEL FINISHES

A. Galvanized Finish: Clean welds, mechanical connections, and abraded areas, and repair galvanizing to comply with ASTM A 780/A 780M.

B. Surface Preparation: Clean surfaces with nonpetroleum solvent so surfaces are free of oil and other contaminants. After cleaning, apply a zinc-phosphate conversion coating suited to the organic coating to be applied over it. Clean welds, mechanical connections, and abraded areas, and repair galvanizing to comply with ASTM A 780/A 780M.

C. Powder Coating: Immediately after cleaning and pretreating, apply two-coat finish consisting of zinc-rich epoxy prime coat and TGIC polyester topcoat, with a minimum dry film thickness of 2 mils (0.05 mm) for topcoat. Comply with coating manufacturer's written instructions to achieve a minimum total dry film thickness of 4 mils (0.10 mm).
1. Color and Gloss: As selected by Architect from manufacturer's full range.
2. Comply with surface finish testing requirements in ASTM F 2408.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for site clearing, earthwork, pavement work, construction layout, and other conditions affecting performance of the Work.

B. Do not begin installation before final grading is completed unless otherwise permitted by Architect.

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

3.2 PREPARATION

A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet (152.5 m) or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.
   1. Construction layout and field engineering are specified in Section 017300 "Execution."

3.3 DECORATIVE FENCE INSTALLATION

A. Install fences according to manufacturer's written instructions.

B. Install fences by setting posts as indicated and fastening infill panels to posts. Peen threads of bolts after assembly to prevent removal.

C. Post Excavation: Drill or hand-excavate holes for posts in firm, undisturbed soil. Excavate holes to a diameter of not less than 4 times post size and a depth of not less than 24 inches (600 mm) plus 3 inches (75 mm) for each foot (300 mm) or fraction of a foot (300 mm) that fence height exceeds 4 feet (1.2 m).

D. Post Setting: Set posts in concrete at indicated spacing into firm, undisturbed soil.
   1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
   2. Concrete Fill: Place concrete around posts and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
      a. Exposed Concrete: Extend 2 inches (51 mm) above grade. Finish and slope top surface to drain water away from post.
   3. Posts Set in Concrete: Extend post to within 6 inches (150 mm) of specified excavation depth, but not closer than 3 inches (75 mm) to bottom of concrete.
   4. Space posts uniformly per manufacturers recommendation but not more than 10 feet o.c.

3.4 GATE INSTALLATION

A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach hardware using tamper-resistant or concealed means.

Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

3.5 GROUNDING AND BONDING

A. Fence Grounding: Install at maximum intervals of 500 feet.
   a. Gates and Other Fence Openings: Ground fence on each side of opening.
      1) Bond metal gates to gate posts.

B. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches (150 mm) below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.

C. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.

D. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
   1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
   2. Make connections with clean, bare metal at points of contact.
   3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
   4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
   5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
   1. Grounding-Resistance Tests: Subject completed grounding system to a megger test at each grounding location. Measure grounding resistance not less than two full days after last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural grounding resistance. Perform tests by two-point method according to IEEE 81.
   2. Excessive Grounding Resistance: If resistance to grounding exceeds specified value, notify Architect promptly. Include recommendations for reducing grounding resistance and a proposal to accomplish recommended work.
   3. Report: Prepare test reports of grounding resistance at each test location certified by a testing agency. Include observations of weather and other phenomena that may affect test results.

3.7 ADJUSTING

A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout

entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

B. Lubricate hardware and other moving parts.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's personnel to adjust, operate, and maintain gates.

END OF SECTION 323119

DIVISION 33 – UTILITIES

SECTION 33 11 00 - WATER UTILITY DISTRIBUTION

PART 1 - GENERAL

1.1. SECTION INCLUDES

A. Trenching, backfill and compaction

B. Water supply piping and fittings

1.2. REFRENCES

A. 2013 California Plumbing Code, California Code of Regulations, Title 24, Part 5

B. Water Utility District Standards: All materials and work shall be in accordance with the water utility district's standard drawings and specifications. The Contractor shall be responsible for obtaining all such standards and for compliance with such standards as applicable.

C. ASTM A126 – Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

D. ASTM A53 / A53M – Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

E. ASTM A197 – Standard Specification for Cupola Malleable Iron

F. ASTM A307 – Specification for Carbon Steel Bolts and Studs, and Threaded Rod 60,000 psi Tensile Strength

G. ASTM D1785 – Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

H. ASTM D2466 – Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40

I. ASTM D2467 – Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80

J. ASTM D2564 – Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings

K. ASTM D2855 – Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings

L. ASTM D3139 – Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals

M. ASTM F477 – Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

N. ANSI/AWWA C110/A21.10 – Standard for Ductile-Iron and Gray-Iron Fittings

O. ANSI/AWWA C111/A21.11 – Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings

P. ANSI/AWWA C153/A21.53 – Standard for Ductile-Iron Compact Fittings for Water Service

Q. AWWA C500 – Gate Valve, 3 through 48 inches NPS – for Water and Sewage System

R. AWWA C508 – Swing-Check Valves for Water Works Service, 2 inches through 24 inches NPS

S. ANSI/AWWA C515 – Standard for Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service

T. ANSI/AWWA C600 – Standard for Installation of Ductile-Iron Mains and Their Appurtenances

U. ANSI/AWWA C605 – Standard for Underground Installation of PVC and PVCO Pressure Pipe and Fittings

V. ANSI/AWWA C606 – Standard for Grooved and Shouldered Joints

W. ANSI/AWWA C651 – Standard for Disinfecting Water Mains

X. ANSI/AWWA C900 – Specification for Polyvinyl Chloride (PVC) Pressure Pipe, 4 in. through 12 in. for Water Distribution

Y. ANSI/NSF 61 – Standard 61 Drinking Water System Components - Health Effects.

Z. NFPA 24 – Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

AA. Underwriters Laboratory (UL)

PART 2 - PRODUCTS

2.1. BEDDING AND BACKFILL

A. Pipe bedding and initial backfill: clean sand in accordance with Section 31 23 33

B. Final trench backfill: clean sand in accordance with Section 31 23 33, or native material if approved by the Geotechnical Engineer

2.2. PIPE

A. Underground installation, 3" and smaller:

1. Pipe: Schedule 40 PVC conforming to ASTM D1785.
2. Fittings: Schedule 40 PVC, Grade 1, conforming to ASTM D2466.
3. Joints: socket welded with PVC solvent cement conforming to ASTM D2564 and ASTM D2855.

B. Aboveground installation, 2” and smaller:
1. Pipe: Galvanized steel conforming to ASTM A53.
2. Fittings: galvanized malleable iron, Class 150, conforming to ANSI B 16.3

3. Joints: threaded

C. Underground installation, 4" through 12":
1. Pipe: PVC bell and spigot Class 150 (DR 18) pipe, conforming to the requirements of AWWA C900.
2. Fittings: mechanical joint ductile iron, conforming to the requirements of AWWA C153/A21.53 and ANSI/AWWA C110/A21.10 with supplement A21.10a for 250 psi working pressure. Ductile iron fittings and specials and flanged bolting assemblies shall be protective coated with coal tar enamel. Fittings shall be by the same manufacturer as the pipe or as recommended by the pipe manufacturer. Fittings shall be installed with a gasket and retaining gland that prevents the pipe from slipping from the fitting.

2.3. GATE VALVES

A. All gate valves shall meet or exceed the latest revision of AWWA Standard C515 for reduced wall, resilient-sealed gate valves (or C509 for resilient-sealed gate valves) and shall be provided with left hand to open, ductile iron (or cast iron) body with epoxy coating inside and out complying with the latest revision of AWWA Standard C550, nut operating non-rising stem with 2” square operating nut, two O-ring stem seals above the thrust collar and one below. O-ring gaskets and 304 stainless steel bolts and nuts on bonnet and stuffing box and EPDM rubber encapsulated wedge. All gate valves shall be manufactured by Mueller Company, M & H Valve and Fitting Company, Kennedy Valve Co., Clow Valve Co., American Flow Control, American AVK Co., or US Pipe.

B. 2 inch and smaller gate valves shall be Class 125 with standard thread, bronze with wheel, and manufactured by Milwaukee (no. 105) or Nibco.

C. Requirement: Gate valves for aboveground or vault installations shall be provided with handwheel operators. Gate valves for underground installations shall be provided with standard square operating wrench nut and shall be cleaned and coated with 2 coats of KopCoat Bitumastic 50.

2.4. CHECK VALVES

A. Check valves: shall be swing type with spring and lever and shall comply with the latest revision of AWWA Standard C508. The valves shall have class 125 flanged ends. Check valves shall be manufactured by Mueller, Clow, or M&H.

B. Valve boxes: All underground valves shall be installed with valve boxes and risers as required. Valve boxes shall be Christy G5T with cast iron traffic lid, or approved equal. Risers shall be 8 inch diameter minimum, Schedule 40 PVC Pipe.

C. Valve operating wrench: CONTRACTOR shall provide one tee handle wrench suitable for operating all buried gate valves.

2.5. BACKFLOW PREVENTER:

A. The backflow prevention assembly for the domestic water system supply line shall be a Reduced Pressure Detector Assembly (RPDA). The assembly shall:

1. be of full line size;

2. consist of two check valves and an automatically operating differential pressure relief valve located between the two check valves;
3. have NRS resilient seat gate valves at each end;
4. be equipped with ports and cocks to allow for testing;
5. conform to AWWA Standard C511-89;
6. be UL listed and approved by the Foundation for Cross-Connection Control and Hydraulic research at the University of Southern California; and,
7. be a Febco, Model 825YD or 860, Watts, Series 909, or approved equal.

2.6. FIRE HYDRANTS, FIRE DEPARTMENT CONNECTION AND POST INDICATOR VALVE

A. Fire Hyrdants shall be CLOW model 960 or City Engineer approved equal.

B. Fire Department Connection: UL listed, labeled or sealed, double clapper Siamese, 90° type, rough bronze body, screwed, labeled "Auto-Spkr", with caps, Potter-Roemer Figure 5735 or equal. Size of connections, threads and mounting height shall be as required by the fire department and NFPA 13.

C. Post indicator and gate valves (if shown): UL listed as manufactured by Muller or equal.

2.7. PROTECTIVE COATINGS

A. All PVC pipe in exterior aboveground installation shall be coated with a material suitable for providing protection from the ultraviolet rays of the sun.

B. All buried metal valves and fittings shall be coated with a coal tar based paint system as follows:

Prime Coat	Kop-Coat Bitumastic 50
Second Coat	Bitumastic 50

C. All private hydrants, sprinkler control valves, detector check assemblies, post indicating values and fire department connections shall be painted OSHA Red.

2.8. ANCHORAGE

A. Anchorages for motor driven and other equipment may be made by using cast-in-place, hot-dipped galvanized anchor bolts or stainless steel type expansion anchors. Sizes and configuration shall be determined by the equipment manufacturer or as indicated on the Construction Drawings.

B. All other anchorages may be made by using cast-in-place, hot-dipped galvanized anchor bolts or stainless steel type expansion anchors. Sizes shall be as indicated on the Construction Drawings or determined by the equipment manufacturer.

2.9. THRUST BLOCKS

A. Minimum 2,500 p.s.i. compressive strength concrete.

2.10. MECHCANICAL JOINT RESTRAINTS

A. EBAA Series 1600 pipe restraints or approved equal.

2.11. WARNING TAPE

A. Provide warning tape and tracer wire as specified in Section 31 23 33.

1. Label: Caution: Water line buried below.

2. Color: Black letters on blue background

PART 3 - EXECUTION

3.1. GENERAL

A. All work shall be in accordance with the applicable provisions of the California Plumbing Code, the jurisdictional water utility owner's standard drawings and specifications, and the product manufacturer’s installation recommendations, except where more stringent requirements are indicated

B. Fire protection system piping and appurtenances shall be installed as recommended by the manufacturer and in accordance with the NFPA 24.

C. Fire department connections shall be installed in accordance with NFPA 13.

3.2. MAINTAINING WATER SERVICES

A. Maintain water service and conduct operations at times selected to minimize the duration and inconvenience of service interruption.

B. At least 24 hours prior to the required cutting or abandoning of an existing water main, notify the jurisdictional water utility owner, and obtain approval of the schedule. Actual cutting or abandoning of an existing water main shall be performed by the Contractor after receiving approval from the owner of the facility.

C. Keep existing water mains parallel to new water mains in service until new water mains are ready for service.

D. Where the existing water main or service is to be cut for connection to new piping, the work shall be performed by the Contractor. Initial work operations shall include the potholing of all points of connection and crossings to ensure the true location of existing linework.

E. Water valves in service shall be operated only by personnel of the jurisdictional water utility owner.

3.3. INSTALLATION

A. Prior to work of this section, carefully inspect previously installed work. Verify all such work is complete to the point where this installation may properly commence.

B. Verify that work of this section may be installed in strict accordance with the original design, all pertinent codes and regulations, and all pertinent portions of the referenced standards.

C. Trench, bed, and backfill pipe in accordance with Section 31 23 33.

D. Top of pipe to finished grade shall be 42 inches minimum for 6” and larger pipe, and 30 inches minimum for smaller pipe, unless otherwise indicated or approved by the Engineer.

E. Provide harnessing (mechanical joint restraint) at elbows, tees, valves, reducers, dead-ends, and other appurtenances of buried piping 4” and larger as required to counteract thrust caused by static and dynamic forces, including water hammer. Provide concrete thrust blocks as indicated where harnessing is not practicable.

F. Install the backflow prevention assembly above ground at the location shown on the drawings, a minimum of 12” and a maximum of 36” above grade measured to the lowest point of the assembly and with adequate side and top clearance to allow access for testing and maintenance.

G. Pipes 4” in diameter and larger which are located within paved areas and with less than 24” of cover measured from the top of pipe to the finished pavement grade shall be backfilled with a controlled density backfill to at least 12” above the top of pipe or to subgrade, whichever is lower.

3.4. TESTING

A. Conduct pressure testing in accordance with the California Plumbing Code, the jurisdictional water utility owner's requirements, and AWWA standards.

3.5. DISINFECTION

A. Disinfect in accordance with the California Plumbing Code, the jurisdictional water utility owner's standard drawings and specifications, and AWWA standards.

END OF SECTION 33 11 00

SECTION 333000 - SANITARY SEWERAGE

PART 1 - GENERAL

3.1 SECTION INCLUDES:

A. Trenching, bedding, and backfill

B. Domestic wastewater (Sanitary Sewage) pipe and fittings

C. Manholes, cleanouts, flushing inlets, and other appurtenances

D. Testing

3.1 REFRENCES

A. California Plumbing Code, 2013 Edition.
B. Standard Specifications for Use in Monterey County Sanitation Districts and Service Areas
C. Standard Specifications and Drawings.

PART 2 - PRODUCTS

3.1 MATERIALS

A. Bedding and backfill
   1. Bedding and backfill shall conform to the Geotechnical Report and pipe manufacturer's recommendations.

B. Pipe
   1. Gravity sewer pipe shall be PVC SDR 35 with rubber gasketed joints conforming to the requirements of the Standard Specifications.
   2. Building sewer pipe shall be either PVC SDR 35 with rubber gasketed joints or ABS solvent weld pipe conforming to the requirements of the Standard Specifications.

C. Manholes

   1. Manholes shall conform to Section 7-03. Manholes of the County of Monterey Standard Specifications and Section 70-1.02H of the State Standard Specifications and constructed in accordance with the Standard Plans and at the locations shown on the Plans. Steps shall not be installed in manholes and pipe may be laid through the manhole and be used as the channel. Concrete manholes for sanitary sewers shall be completely coated inside with fiberglass liner with United Coatings Elastuff 120. Elastuff Hydrophobic Polyurethane Elastomer with Uni-Tile Sealer, Raven 405 one hundred percent (100%) solid epoxy, or approved equal. Coating shall include all concrete interiors from flowline to manhole cover. Existing manholes shall be adjusted to grade, re-modeled, or abandoned as shown on the Plans. Existing sanitary sewer manhole to be reused that has not been coated shall be cleaned and completely coated inside with Lafarge Sewer Coat calcium aluminate cements and aggregates or approved equal by the Engineer.
   2. Manhole lids shall be bolt down in accordance with Detail 7 – Bolt-Down Manhole Cover of the Project Plans.

D. Accessories
   1. Accessories such as cleanouts, flushing inlets, and other appurtenances shall conform to the California Plumbing Code, the details shown on the Construction Drawings, and the Standard Drawings.
   2. Debris Catcher: Max-Life MDCP-10 and fiberglass pole or approved equal.
   3. Provide continuous 3”-wide marking tape 12” above all underground pipes conforming to the requirements of 31 23 33-3.9 Buried Warning and Identification Tape of these specifications and Section 3.05B.4 of the Standard Specifications.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The bottom of the pipe trench shall provide a firm full-length bearing for the pipe between connections, with holes excavated to relieve the stresses caused by the joint connection.
B. Joints for cast iron pipe shall be made with pure lead poured in accordance with commonly accepted standards. Joints in other types of pipe shall be made in accordance with manufacturer’s recommendations and with commonly accepted standards.
C. Pipe laying shall proceed upgrade with bell end forward.
D. Utilities and culverts, both private and public, shall be protected from damage and maintained in service.
E. The pipe shall be laid on an even grade when practicable. Abrupt changes in grade shall be made by using curved pipe.
F. Minimum cover for lateral sewers shall be thirty (30) inches measured from the top of the pipe to finish grade.
G. No backfill shall be placed until the sewer has been inspected and approved by the engineer. Selected backfill shall be carefully placed and thoroughly tamped for a minimum of one foot above the pipe.

3.2. TESTING

A. Unless specifically waived by the Architect, all pipes and manholes shall be tested in accordance with Section 12, Testing of the County of Monterey Standard Specifications for use in Monterey County Sanitation Districts and Service Areas.

END OF SECTION 333000

SECTION 334000 - STORM DRAINAGE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Trenching, backfill, and compaction

B. Storm drain piping

C. Drainage structures including manholes, inlets, catch basins, and cleanouts

1.2 REFRENCES

A. Standard Specifications, State of California, Department of Transportation (CalTrans), 2010 Edition.

B. ASTM C478 – Standard Specification for Circular Precast Reinforced Concrete Manhole Sections

C. ASTM D2241 – Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)

D. ASTM D2321 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

E. ASTM D3034 – Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings

F. ASTM D3212 – Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals

G. ASTM F1668 – Standard Guide for Construction Procedures for Buried Plastic Pipe.

1.3 SUBMITTALS

A. Submit manufacturer’s cut sheets for all products proposed

B. Submit concrete mix design and shop drawings for any cast-in-place concrete structures proposed

PART 2 - PRODUCTS

2.1 MATERIALS

A. Bedding and Backfill
   1. Pipe bedding and initial backfill: Clean sand in accordance with Section 312333
   2. Final backfill: Clean sand or approved native material in accordance with Section 312333.

3. In no event shall bedding or backfill materials conform to ASTM D2321 Class IV material.

B. Storm Drain Pipe

1. Storm drain pipe, 6” and larger: Type ‘S’ HPDE Pipe with watertight (WT) joints conforming to Section 64 of the Standard Specifications.
    a) Alternate: 4" and larger: Polyvinyl Chloride (PVC) gravity sewer pipe and fittings conforming ASTM D3034, SDR 35.

C. Cleanouts: Materials for cleanouts shall be in accordance with the California Plumbing Code and the details shown on the Construction Drawings. Cleanout risers shall be of the same material as the adjacent pipe line.

D. Drainage Structures

1. Plastic drainage structures, 4” to 8” Diameter: In-line drains as manufactured by ADS (Nyloplast), with black frames and covers as indicated on the Construction Drawings
2. Precast concrete drainage structures: Precast concrete drainage inlets and junction boxes as manufactured by Central Precast, with covers or grates as indicated on Construction Drawings, or approved equal.
3. Cast-in-place drainage structures may be utilized in lieu of precast concrete structures if approved in advance by the ARCHITECT. Cast in place concrete structures shall conform to Section 51-7, “Minor Structures” of the Standard Specifications and to the details on the Construction Drawings. Concrete shall be Class 2. Contractor shop drawings shall be required for approval for any cast-in-place concrete structure.
4. Provide butyl rubber joint sealant such as CONSEAL between sections of precast concrete units.
5. Provide water tight connections such as A-LOK or KOR-N-SEAL at connections to concrete structures.
6. Grates within pedestrian areas shall be ADA compliant.
7. Grates within vehicular areas shall be H-20 traffic rated.
8. Metal grates and lids shall be lock down or tamper proof as approved by the Architect.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All work related to the storm drainage systems shall be performed in accordance with the requirements of Section 312333 - Trenching, the referenced Standards, the Manufacturers’ Specifications and Recommendations, the Geotechnical Report, and the Construction Drawings.

B. Storm drain pipes located within vehicular areas and with less than 24” of cover measured from the top of pipe to the finished pavement grade shall be backfilled with minor concrete to at least 6” above the top of pipe or to subgrade, whichever is higher.

C. END OF SECTION 334100

SECTION 334616 - SUBSURFACE DRAINS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Subsurface drains for walls, foundations, and rain gardens.

1.2 REFRENCES

A. Standard Specifications, State of California, Department of Transportation (Caltrans), 2010 edition

PART 2 - PRODUCTS

2.1 MATERIALS

A. Non-Perforated Pipe: PVC Schedule 40 pipe, ABS sewer pipe, or PVC SDR 35 sewer pipe per Section 334000. Size shall be as specified on the Construction Drawings; if not specified, pipe shall be the same size as the upstream perforated pipe.

B. Perforated Pipe: 4”-diameter PVC Schedule 40 pipe perforated with 3/8 inch diameter holes in 2 rows at the ends of a 120 degree arc, at 3 inch centers in each row, staggered between rows. Holes shall be placed downward.

C. Drain Rock: 3/8 to 3/4 inch clean, crushed gravel approved by the GEOTECHNICAL ENGINEER

D. Filter Fabric: Mirafi 180N or equivalent

E. Visqueen: 10 mil Visqueen or equivalent

2.2 ACCESSORIES

A. Cleanout boxes: Christy G5 with metal lid marked "SDCO".

B. Cleanout risers: 4-inch diameter non-perforated pipe. Cleanout risers shall be of the same material as the adjacent horizontal line.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The subsurface drains shall be installed and backfilled with a minimum width of 12 inches of drain rock. The base of the subsurface drain shall be embedded a minimum of 6 inches into the underlying clays. The subsurface drain should be a minimum of 5' from the structures. The drain rock shall be fully encapsulated in filter fabric and shall be capped with a minimum of 12 inches of native compacted soil. The drain rock shall be placed and compacted as specified in Section 31 23 33.

B. Perforated pipe shall be laid with perforations down, within 4 inches of the bottom of the drain rock. The pipe shall outlet to a suitable, approved location.

C. Lengths of pipe shall be joined by couplings if they do not have integral bell ends.

D. Pipe discharge lines shall be laid in trenches and backfilled with compacted soil approved for the specific use by the GEOTECHNICAL ENGINEER.

E. Where noted on the Plans, place Visqueen on the downslope side and bottom of the trench excavation.

3.2 OBSERVATION

A. The CONTRACTOR shall inform the GEOTECHNICAL ENGINEER of his intent to install subsurface drains and shall receive approval prior to commencement of installation.

B. The GEOTECHNICAL ENGINEER will observe the installation of subsurface drains and will test the quality and compaction of the materials used.

END OF SECTION 334616