DIVISION 16

ELECTRICAL

SECTION 16050
BASIC ELECTRICAL MATERIALS AND METHODS

1.00 GENERAL

1.01 SECTION INCLUDES

A. General requirements for Electrical work including:

1. Drawing intent.
2. Arrangement of work.
3. Quality assurance.
4. Definitions.
5. Regulatory requirements.
6. Special warranties.
7. Delivery/Storage/Handling/Protection.
8. Material and equipment not specified under Division 26.
9. Coordination.
10. Design modifications.

B. Grounding system.

C. Supporting devices.

D. Sleeves, seals and escutcheon plates.

E. Trenching for underground electric utilities.

F. Cast-in-place concrete for electrical work.

G. Corrosion resistant coatings.

H. Field painting of certain electrical work.

I. Roof penetration counterflashing.

1.02 REFERENCE SPECIFICATIONS: Unless specified otherwise, follow:

A. Section 03300 - Cast-In-Place Concrete, for cast-in-place concrete equipment bases.

B. Section 07720 - Roof Specialties and Accessories, for counterflashing of roof penetrations.

C. Section 02200 - Earthwork, for earthwork for underground utilities.

1.03 RELATED SECTIONS

A. Section 01310 - Coordination and Meetings, for scheduling “Shutdowns”.

B. Section 07841 - Firestopping and Firesafing, for firestopping around penetrations through fire rated construction.

C. Section 07790 - Joint Sealers, for joint sealers around penetrations through non-fire rated construction.

D. Section 081311 - Access Doors.

E. Section 16075 - Electrical Identification.

F. Section 16511 - Lighting, for supporting devices for interior lighting fixtures.

1.04 SUBMITTALS: Follow Section 01330.

A. Shop Drawings: Continuous slot channel mounting structures.

B. Product Data: Describe grounding materials and continuous slot channel.

C. Reports: Megger readings of grounding system.

D. Schedules: Access door schedule if required.

E. Informational Submittals; Certificates: Certify that grounding system field tests and inspections specified have been performed and that work meets or exceeds specified requirements. Attach reports as specified.

1.05 DRAWING INTENT

A. Drawings are diagrammatic and indicate general arrangements, approximate sizes, and relative locations of principal elements. Provide items such as pull boxes, offsets to clear interference, and supports which are not specifically shown but which are required to make systems complete and operable.

B. Electrical riser and schematic diagrams generally indicate equipment and wiring for various systems. Provide work shown on diagrams, whether or not duplicated on Drawings and vice versa.

C. Electrical systems are indicated on Electrical Drawings. Certain pertinent information and details required by electrical work appear on Site, Architectural, Structural, and Mechanical Drawings. Refer to all drawings.

1.06 ARRANGEMENT OF WORK

A. In addition to requirements specified below, follow Section 01310 for other requirements regarding coordination of space and for spacing of hangers and load limitations.

B. Conceal electrical construction running through finished spaces within walls or chases. At suspended ceilings, conceal work above ceiling unless indicated "at ceiling", in which case, work shall be exposed below ceilings.

C. In finished spaces with or without ceilings, coordinate with other work. Follow reflected ceiling plans.

D. In finished spaces without ceilings, install wiring, conduit, and other work parallel with building lines.

E. Where physical interference cannot be resolved readily, prepare composite drawings at a scale of not less than 1/4 inch equals 1'-0 or 1:50. Show work of this Division in relation to other work. Obtain written approval by of proposed changes. Distribute drawings to other trades affected. Correct conflicts at no additional cost.

F. Subject to approval and without extra cost, make modifications in layout as required to prevent conflict with other work or for proper execution of work.

G. Division 16 does not permit the following conditions. Advise A/E and the Owner in writing when:

1. Piping, ductwork, or equipment foreign to electrical construction has been installed in electrical equipment rooms or electrical closets.
2. Piping or ductwork, has been installed over, around, in front of, in back of, or below electrical controls, panels, switches, terminals, boxes or similar electrical equipment.
3. Drip pans have been installed over or around electrical equipment.

H. Position electrical work for easy unobstructed operation of the building. Obtain required location information sufficiently in advance of installation to allow uninterrupted progress.

I. Check layouts of equipment with shop drawings of other trades to determine roughing-in requirements. Do not scale drawings for exact locations. Provide a neat arrangement of work to overcome local interference to best advantage of the Project.

J. Position lights, smoke detectors, loudspeakers, and similar equipment as shown on reflected ceiling plan. Arrange ceiling outlets symmetrically.

K. Verify locations of floor outlets with A/E before roughing-in.

L. Locate switches and other manually operated devices in a location easily accessible and convenient to operating personnel. If any such devices are mounted in locations not approved, relocate devices at no additional cost.

M. Do not install aluminum or copper products where they will be encased in concrete.

1.07 COORDINATION WORK

A. Provide engineered coordination of building equipment and laboratory equipment load and provide design for future loads. For design purposes, electrical service is expected to require 50 percent redundancy to be rliable. Qualified engineers who are determining the size of switchgear equipment, the distribution equipment, emergency generator, and Automatic Transfer Switch (ATS) are to carefully selecte compatible products from manufacturer(s.) Careful selection of electrical overcurrent devices is a way to ensure proper equipment and personnel protection. A short circuit study per IEC 60909, ANSI C37, and IEEE 141 standards could support electrical design. Submit curves and study for review. Provide distances and pertinent information required.

B. Submit preliminary coordination and load study prior to submission of shop drawings.

C. Sizes of fuses, breaker interrupting rating, and bus bracing shown are minimum. Provide exact sizing according to a preconstruction coordination study.

D. Any changes to Contract Documents or equipment, as a result of coordination study after bids are awarded, shall not result in additional cost.

E. Contact A/E immediately if any delay occurs due to lack of information required to complete this study.

F. Include one line system diagram, short circuit and ground fault analysis, and protective coordination plots.

G. Present organized time-current analysis of each protective device in series from main circuit breaker in branch circuit panelboard - back to Utility Company devices protecting service, including on-site service, main and feeder circuit protective devices.

1.08 QUALITY ASSURANCE: Unless more stringent provisions are shown or specified, provide work in accordance with the following standards. Date of each standard is that in effect as of Bid date, or date of Construction Contract Agreement when there are no bids, except when a specific date is specified.

A. American National Standards Institute (ANSI).

B. Factory Insurance Association (FIA).

C. Factory Mutual System (FM).

D. Industrial Risks Insurance (IRI).

E. Institute of Electrical and Electronic Engineers (IEEE).

F. Insulated Cable Engineers' Association (ICEA).

G. National Electrical Code (NEC), including amendments by local authority having jurisdiction.

H. National Fire Protection Association (NFPA).

I. National Electrical Manufacturers' Association (NEMA).

J. National Sanitation Foundation (NSF), now known as NSF International.

K. Local power company.

L. Local telephone company.

M. Underwriters Laboratories Inc. (UL): All material and equipment shall be listed, labeled or certified by Underwriters Laboratories, Inc., where such standards have been established. Equipment and material which are not covered by UL Standards will be accepted, provided equipment and material is listed, labeled, certified or otherwise determined to meet safety requirements of a nationally recognized testing laboratory. Equipment of a class which no nationally recognized testing laboratory accepts, certifies, lists, labels, or determines to be safe, will be considered if inspected or tested in accordance with national industrial standards, such as NEMA, or ANSI. Evidence of compliance shall include certified test reports and definitive submittals.

1.09 DEFINITIONS

A. Listed: Equipment is "listed" if of a kind mentioned in a list which:

1. Is published by a nationally recognized laboratory which makes periodic inspection of production of such equipment.
2. States that such equipment meets nationally recognized standards or has been tested and found safe for use in a specified manner.

B. Labeled: Equipment is “labeled” if:

1. It embodies a valid label, symbol, or other identifying mark of a nationally recognized testing laboratory such as Underwriters Laboratories, Inc.
2. Production is periodically inspected by a nationally recognized testing laboratory.
3. The labeling indicates compliance with nationally recognized standards or tests to determine safe use in a specified manner.

C. Certified: Equipment is “certified” if:

1. Equipment has been tested and found by a nationally recognized testing laboratory to meet nationally recognized standards or to be safe for use in a specified manner.
2. Production is periodically inspected by a nationally recognized testing laboratory.
3. It bears a label, tag, or other record of certification.

D. Nationally recognized Testing Laboratory: A testing laboratory which is listed by OSHA as a National Recognized Testing Laboratory.

1.10 REGULATORY REQUIREMENTS: Comply with:

A. National Electrical Code (NEC); including amendments by local authority having jurisdiction.

B. Local inspection authorities.

C. Local electrical utility company.

D. University of the Philippines System administration, planning and facility management.

1.11 SPECIAL WARRANTIES

In addition to Special Warranty provisions of individual specification Sections, and when manufacturer of any piece of equipment normally offers a warranty on such equipment or any part thereof for a period of more than one year, furnish copy of such warranty, following Section 01750.

1.12 DELIVERY, STORAGE, HANDLING, AND PROTECTION

A. Prior to installation, comply with Section 01600. After installation, comply with Section 01500.

B. After cabinets and boxes are installed, cover openings to prevent entrance of water and foreign materials.

C. Provide temporary enclosures for equipment such as substations, motor control centers, and emergency generators. Provide and maintain heat in enclosures until equipment is energized, to avoid condensation damage.

1.13 MATERIALS AND EQUIPMENT NOT SPECIFIED UNDER DIVISION 16

A. Where shown or specified, install electrical work in or on equipment furnished under other specification sections, or by Owner. Obtain installation instructions from party furnishing equipment.

B. See Section 16141 Wiring for Electrical Connections.

1.14 COORDINATION: Follow Section 01310.

A. Carefully examine Drawings of other trades for equipment requiring electrical connection, and ascertain that electrical characteristics of equipment scheduled thereon matches the service available. If any discrepancies are noted, immediately refer to A/E for resolution. If characteristics are correct, ascertain method of connection, "rough-in" dimensions, correct plug and receptacle configurations, and other conditions. While A/E has made every effort to provide

such information as is known at time of design, final data must be obtained from shop drawings before proceeding.

B. The responsibility of this Section includes obtaining required electrical characteristics of all electrically driven equipment on this Project, whether furnished under Division 16, other specification sections, or directly by the Owner, and for the correction of all problems arising from failure to do so.

C. Access Doors: Coordinate with Section 08311. In general, arrange work so access doors are not required. Where electrical devices requiring access must be concealed in finished construction, coordinate with other trades, and provide schedule showing size and location of each door.

1.15 DESIGN MODIFICATIONS

A. Electrical systems supply, control, and/or monitor systems specified elsewhere, and are based on specific manufacturer's data. Where any agreement or change is made to supply equipment of larger capacity or different electrical characteristics, provide electrical system required to effect such changes within the intent of the Contract Documents. For example, if HVAC system motor is allowed to change from 50 hp to 60 hp, provide combination motor starter and wiring to accommodate change at no additional cost.

B. Inform A/E of record in writing of such changes.

2.00 PRODUCTS

2.01 GROUNDING SYSTEM

A. Manufacturers: Substitutions are permitted subject to General Requirements Div 00 Section 01000 Explanation to the Specifications..

1. Blackburn.
2. Burndy.
3. Cadweld.
4. Chance.
5. Hubbard.
6. O.Z./Gedney.
7. Steel City.
8. T & B.

B. Standards: NEC Article No. 250.

C. Materials: Non-ferrous copper and its alloys; no aluminum.

D. Ground Rods: 19 mm x 3050 mm (3/4 inch x 10 feet) copperweld.

E. Grounding Conductors: Code gauge stranded copper wire, bare or with green insulation. No aluminum conductors.

F. Ground Clamps and Connectors: Multiple bolt type. Clamps for pipe, lugs for flat surfaces, saddle clamp or compression type for wire.

G. Conduit Ground Bushings: Galvanized malleable iron with screw pressure connector; insulated throat where required.

H. Buried Splices: Thermoweld.

I. Exposed Splices: Acceptable ground clamps and connectors.

J. Connections to Building Steel Construction: Thermoweld.

2.02 SUPPORTING DEVICES

A. Provide devices, anchors and fasteners to support equipment and conduit loads. Include weight of wire in conduit when selecting product size and type.

B. Continuous Slot Channel:

1. Manufacturers: Substitutions are permitted subject to Section 01000.
   a. B-Line.
   b. T&B Superstrut.
   c. Unistrut.
2. Material: Formed steel, 41mm x 2.7 mm (1 5/8 inches x 12 gauge).
3. Finish: Primer and baked enamel. Hot dip galvanized where shown.
4. Accessories: Manufactured fittings as required, including spring-loaded nut and bolt assemblies.
5. Other Types: As shown.
6. Option: In lieu of slot channels, welded assemblies using prime painted steel angles or channels are approved.

2.03 CONDUIT SLEEVES - ABOVE GRADE

A. Pre-fabricated Patented Sleeves: Manufacturer; Thunderline. Substitutions are permitted subject to Section 01000.

1. Exterior Walls and Floors (Non Fire Rated):
   a. Sleeves 25 mm through 560 mm (1 Inch through 22 Inches): Thunderline Model WS, Galvanized Steel Sleeve.
   b. Sleeves 580 mm (23 Inches) and Larger: Thunderline Model WS, Galvanized Steel Sleeve. Seals: Thunderline Model Link-Seal, modular, mechanical type, multiple interlocking synthetic rubber, expandable links matched for sleeve assembly.

c. For Standard Service Applications (-40 to 250 degrees F) EPDM or Fire Seal Applications (-67 to 4000 degrees F) silicone.

2. Interior to Interior Sleeves (Walls): Fire rated and non-fire rated construction; steel pipe or 1.2 mm (18 gauge) galvanized steel.

3. Floor and Roof Sleeves: Steel pipe with welded-on collar to position top of sleeve 50 mm (2 inches) above floor slab, and 200 mm (8 inches) above roof deck. Make bottom of sleeve flush with underside of roof or floor deck.

B. Size of Interior Diameter (ID): 13 mm to 19 mm (1/2 inch to 3/4 inch) larger than penetrating element.

2.04 ESCUTCHEON PLATES

A. One piece, set screw type; chrome plated steel in finished spaces; cast brass in unfinished; none required in concealed areas.

2.05 ACCESSORY MATERIALS

A. Bedding and Backfilling Materials: As specified in Section 31 23 16 [31 05 00].

B. Concrete: Mix 4.0 as specified in Section 03 30 00.

C. Anchors and Sleeves: Hook type anchor bolts with pipe sleeves of proper size and length to suit equipment. Make sleeves one inch larger than bolt diameter and half imbedded length of bolt, to allow for lateral adjustment.

D. Concrete Reinforcing for Housekeeping Pads: Welded wire mesh, 6 x 6 W1.4 x W1.4.

E. Field Painting Materials: As specified in Section 09910 as applicable.

F. Corrosion Resistant Coating: Brush or roller grade, liquid asphalt.

3.00 EXECUTION

3.01 INSTALLATION - GENERAL

A. Install work mechanically and electrically correct, and in a neat, workmanlike manner. Make changes and reinstallation to work not approved.

B. Install equipment in strict accordance with manufacturer's instructions for type and capacity of each piece of equipment used. Obtain instructions from manufacturers, and consider them part of these specifications.

C. Where existing equipment, piping, conduit, ductwork, and similar materials require moving for installation of new work, remove these items as required, and restore them to original location

and condition. Patching of fire-rated assemblies shall restore the fire-resistive rating of the fire-rated assembly.

3.02 GROUNDING SYSTEM

A. Provide a complete grounding system in accordance with NEC Article 250 and authorities having jurisdiction.

B. Provide reliable, low impedance, metallic, ground path for short circuit currents so that circuit protective devices can operate quickly and effectively. Route ground path parallel to circuit conductors and as physically close to them as possible, generally using metallic conduit system as a conductor. Make ground path continuous from service entrance equipment, through distribution system, to each outlet and electrically operated device and enclosure in the Project.

C. Provide a grounding conductor in each of the following conduits. Connect to grounding system at each end.

1. Each run of non-metallic conduit.
2. Each feeder from main switchboard to each substation, distribution switchboard, panelboard, and other equipment shown.
3. Each feeder to a distribution transformer.
4. Each run that includes a section of flexible or liquidtight conduit, unless conduit and fittings are UL approved for grounding.
5. Additional grounding conductors as shown.

D. Provide ground rods where indicated, in sufficient number to obtain required ground resistance. In spaces accessible to authorized personnel only, leave top 6 inches of rod exposed for visual inspection of connection. In other locations, bury top of rod at least 6 inches below top of finished construction. Interconnect rods in each group with ground cable.

E. Maximum ground resistance at each cluster of ground rods; 5 ohms when measured with a "Megger". Take readings when ground is dry, at least 48 hours after rain or 48 hours after snow has melted. Record measurement and date of reading for each rod cluster, and submit test report. Maximum permissible resistance: Equipment 2 ohms; ground return in buildings 0.1 ohms.

F. Provide schedule 40 PVC conduit stub-ups for terminating single bare conductor ground wires. Grounding type bushings are not required for PVC conduits only.

G. Use approved grounding connectors. Clean surfaces bright before installing. Touch up painted surfaces after installation.

H. Size grounding conductors in accordance with NEC unless larger sizes are indicated. In general, use bare wire. Where insulated wire is required, use green color code.

I. At service equipment, interconnect grounding conductor with system neutral and equipment grounding conductor. Bond enclosures of service equipment. Where multiple knockouts are

used, provide grounding bushings on conduit, and interconnect with equipment grounding conductor. Connect neutral on supply side of service switch. Keep neutral insulated from ground on load side of service switch, except at transformers for separately derived systems.

J. From service entrance equipment, provide two separate full size grounding electrode conductors in separate conduits to water service into building. Connect to metallic piping ahead of water meter. Provide ground rod at water entrance, and connect to grounding electrode conductors. Provide jumper around water meter and associated valves.

K. At substations, switchboards, motor control centers, and similar equipment, connect to ground bus inside equipment enclosure. Ground metering, transformer neutral, transformer ground pad, grounding devices, and non-current carrying metal parts including frame of enclosure, conduit, grounding conductors, and the like. Provide grounding bushings on metallic conduit, and interconnect with ground wire to ground bus.

L. At distribution transformer, interconnect transformer neutral with grounding conductor of primary circuit and with bonding conductor of transformer enclosure. Extend grounding conductor to connection with building structural steel. Ground to nearest steel building column.

M. Ground frames of motors. Conduit system is approved if connection box is bolted to motor frame. In other instances, provide grounding bushing on conduit, and extend grounding conductor to a bolt on frame of motor. Where motor is part of apparatus, such as an air handling unit, ground enclosure using connector furnished by manufacturer. Provide connector if none is furnished.

N. Ground steel building columns where indicated. Provide ground rod adjacent to column, and attach No. 4/0 grounding conductor to web of column with thermoweld connector. Attach connector to column below level of floor slab.

O. Bond building steel at expansion joints approximately 100 feet OC. Provide braid of appropriate length, and fasten to flange of principal steel member on each side of joint.

P. At convenience receptacles, extend ground wire from grounding screw of receptacle to grounding connector of box.

Q. At exterior lighting standards, provide grounding bushing on conduit, and interconnect ground wire to grounding connector in base of pole. Provide ground rod at pole where indicated, and interconnect to grounding connector in pole. Connection at ground rod shall be thermoweld.

R. At generator, connect frame and neutral point of generators to ground.

S. Provide other grounding methods as required.

3.03 SUPPORTING DEVICES

A. Support material from building structural system in accordance with NEC. Do not support material from joist bridging, ductwork, piping, or conduit. Do not drill structural steel members.

B. Where electrical equipment is mounted in suspended ceiling panels, provide support members to span between framing members of ceiling suspension system. Do not support electrical equipment from acoustical panels or other ceiling material; attach to suspension system only. Securely fasten support members to framing members.

C. Do not support electrical outlet boxes, cables, or conduit from suspension wires of ceiling suspension system. Do not attach work in such manner as to prevent removal of ceiling panels.

D. Where electrical outlet boxes, and other equipment are installed on ceiling suspension system, use independent support clips with threaded studs. Do not attach to suspension system except for alignment. Use clips that snap around suspension system and have provisions for independent support wire. Attach a suitable anchor in structure above ceiling. Suspend a minimum No. 12 support wire to engage each clip.

E. Provide a separate individual support for every junction and pull box. Support boxes with acceptable clamps or threaded rod. Do not use individual wire supports connected into ceiling grid.

F. Provide mounting structures for electrical equipment where required. Use continuous slot channel or fabricated assembly.

G. Provide 1/4 inch spacers behind surface mounted cabinets of electrical equipment to permit circulation of air.

H. Suspension Racks: Provide racks of continuous slot channel for parallel runs of conduit. Suspend on adjustable hangers.

I. Use adjustable clevis hangers for individual runs of suspended conduit. Align suspended runs in horizontal plane for neat appearance.

J. Use acceptable beam clamps for connection to structural steel.

K. Use minimum 3/8 inch rod for vertical supports; no perforated strap.

L. Determine locations of anchors, inserts, and supports. Maintain locations during construction.

M. Use supporting hardware suitable for purpose intended. Use expansion shields with machine screws at concrete or solid masonry; toggle bolts at hollow masonry; lag bolts at wood surfaces. Use approved methods for other conditions as required. Do not use wood, plastic or fiber plugs.

N. Do not exceed manufacturer's load rating for mounting devices.

O. In cast concrete, use box inserts which allow lateral adjustment of the threaded member for proper alignment. Use continuous box inserts where required.

P. Use support systems adequate for weight of equipment, conduit, and wiring.

3.04 SUPPORTS AT GYPSUM BOARD CONSTRUCTION

A. Provide support members to carry weight of equipment; do not rely on gypsum board for support. Attach to gypsum board for alignment purposes only. Mount equipment on support members spanning two studs, or attach directly to studs.

B. Equipment normally supported from outlet boxes will require no additional support. Attach outlet boxes directly to framing members. Provide heavy duty, slotted channel support member to span between framing if required for location of box. Bridge framing at top and bottom with channels to support flush mounted cabinets and panelboard.

C. Where equipment cannot be supported by attachment to outlet box alone, coordinate supports with general construction. Maximum weights as indicated below:

1. Recessed equipment, attached to one stud: 100 pounds.
2. Recessed equipment, attached to two studs: 500 pounds.
3. Recessed equipment, greater than 500 pounds: Provide independent mounting structure inside gypsum board construction.
4. Surface mounted equipment, attached to two studs: 100 pounds.
5. Surface mounted equipment, greater than 100 pounds: Provide independent mounting structure outside gypsum board construction.

3.05 CONDUIT SLEEVES, SEALS, AND ESCUTCHEONS

A. Sleeves: Furnish sleeves to other Sections as appropriate for installation. Space sleeves in concrete at least 4 inches apart. Where gypsum board is installed on one side of stud partition only, provide traditional sleeve support as required.

B. Seals: Install mechanical seals around conduit passing through below grade structure, in such manner to ensure watertight installation.

C. Escutcheon Plates: Install plates tight to wall or ceiling surface.

3.06 HOUSEKEEPING PADS

A. Provide concrete pads for floor mounted electrical equipment in dimensions indicated, but not less than 4 inches thick and extending 4 inches beyond supported equipment outline unless otherwise shown.

B. Use equipment manufacturer's setting templates for anchor bolt and tie locations.

C. Roughen base slab before placing concrete, using pneumatic equipment to remove 1/2 to 1 inch of material.

D. Place concrete and install wire mesh one inch below finished surface.

E. Apply hand trowel finish as specified in Section 03 30 00.

3.07 MISCELLANEOUS CONCRETE WORK

A. Provide other concrete work required for electrical construction.

3.08 CORROSION RESISTANT COATING

A. Apply two coats to metal conduit in direct contact with earth.

3.09 FIELD PAINTING

A. Except as specified below, and under Electrical Identification, field painting required for electrical construction is specified under Section 09 91 00.

B. Paint exposed conduit bright orange where conductors are rated in excess of 600 volts.

C. Paint boxes, covers, and conduit as specified under Electrical Identification.

3.10 ROOF PENETRATION COUNTERFLASHING

A. When roof mounted work is not furnished with integral counterflashing, provide metal counterflashing as specified under Section 07620.

END OF SECTION 16050

SECTION 16055
OVERCURRENT PROTECTIVE DEVICE COORDINATION AND ARC FLASH ANALYSIS

1.00 GENERAL

1.01 SCOPE OF WORK

A. This Section includes computer-based, fault-current and overcurrent protective device coordination studies. Protective devices shall be set based on results of the protective device coordination study. The study shall include an arc-flash hazard analysis to determine the minimum recommended personal protective equipment required when examining, adjusting, servicing of maintaining energized equipment. The arc-flash hazard calculations and analysis shall be performed based on the IEEE Standard 1584-2002. Coordination of series-rated devices is not allowed.

B. The study shall present an organized time current analysis of each protective device in series from the individual device at each item of equipment back to the source. The study shall reflect the operation of each device during normal and abnormal current conditions including normal and abnormal power conditions (normal and emergency systems).

C. Protective equipment shop drawings shall be submitted simultaneously with the protective device study.

D. Certification: Two weeks prior to final inspection, deliver four (4) copies of the following certifications to the Engineer of Record and the Owner.

E. Certification by the Contractor that the oritective devices have been adjusted an dset in accordance with the approved protective device study.

F. The results of the power system shall be summarized in a final report. Five (5) bound copies of the final report shall be submitted. The final report shall contain all information required under this section. All full size drawings shall be bound in the report and folded to fit. Coordination plot drawings shall be bound in the report and folded to fit. One electronic copy of the report shall be submitted with the final report.

1.02 SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.

C. Qualification Data: For coordination-study specialist.

D. Other Action Submittals: The following submittals shall be made after the approval process for system protective devices has been completed. Submittals shall be in digital form including

1. Coordination-study input data, including completed computer program input data sheets.
2. Study and Equipment Evaluation reports.
3. All software data used, libraries, reports and single-line diagrams in electronic

format so that the Owner will have a means to have the data modified in the future as changes to the system occur.

4. Coordination Study Report.

5. Arc-Flash hazard Analysis Report.

1.03 QUALITY ASSURANCE

A. Coordination –Study Specialist qualifications: An entity experiences in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. Professional engineer, licensed in the Philippines, shall be responsible for the study. All element of the study shall be performed under the direct supervision and control of the engineer. The study shall be sealed by the Professional Engineer.

B. Comply with IEEE 242 for short-circuit current and coordination time intervals.

C. Comply with IEEE 399 for general study procedures.

1.04 REQUIREMENTS

A. General

1. The complete study shall include system protective coordination plots. The protective devices coordination plots shall be prepared under full size coordination curves supplied by the device manufacturer. Coordination curves shall be computer generated,

B. Coordination Curves:

1. The coordination curves shall be prepared to determine the required settings of protective devices to assure selective coordination. The curves shall graphically illustrate on log log paper that adequate time separation exists between series devices, including the utility company upstream devices.
2. The specific time current characteristics of each protective device shall be plotted in such a manner that all upstream devices will be clearly depicted on one sheet.
4. The following device information shall also be shown on the coordination curves:
   a. Voltage and current ratio for curves.
   b. 3 phase and 1 phase ANSI damage points for each transformer.
   c. No damage, melting, and clearing curves for fuses.
   d. Cable damage curves.
   e. Transformer inrush points.
   f. Maximum short circuit cut-off point.

C. A table shall be developed to summarize the settings selected for the protective devices. Included in the table shall be the following. Included in the table shall be device identification, circuit breaker settings, fuse rating and type.

D. Analysis - After developing the coordination curves, areas lacking coordination shall be highlighted. Technical evaluation of the reason for the lack of coordination shall be presented, and logical alternatives shall be discussed.

E. Adjustments, Settings and Modifications: The Contractor shall provide the services of a qualified factory service engineer and necessary tools and equipment to test, calibrate and adjust the protective relays and circuit breaker trip devices as recommended in the

power system study. Necessary field settings, adjustments, and modifications, for conformance with the study shall be accomplished without additional cost to the Owner.

2.00 PRODUCTS

2.01 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399.

B. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

1. Optional Features:

a. Arcing faults.
b. Simultaneous faults.
c. Explicit negative sequence.
d. Mutual coupling in zero sequence.

3.00 EXECUTION

3.01 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.02 POWER SYSTEM DATA

A. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 16 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.

2. Impedance of utility service entrance.

3. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:

a. Circuit-breaker and fuse-current ratings and types.
b. Relays and associated power and current transformer ratings and ratios.
c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.

d. Generator kilovolt amperes, size, voltage, and source impedance.
e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.
f. Busway ampacity and impedance.
g. Motor horsepower and code letter designation according to NEMA MG 1.

4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
   a. Special load considerations, including starting inrush currents and frequent starting and stopping.
   b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
   c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
   d. Generator thermal-damage curve.
   e. Ratings, types, and settings of utility company's overcurrent protective devices.
   f. Special overcurrent protective device settings or types stipulated by utility company.
   g. Time-current-characteristic curves of devices indicated to be coordinated.
   h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
   i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
   j. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

3.03 FAULT-CURRENT STUDY

A. Calculate the maximum available short-circuit current in amperes rms symmetrical at circuit- breaker positions of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:

   1. Switchgear and switchboard bus.
   2. Motor-control center.
   3. Distribution panelboard.
   4. Branch circuit panelboard.

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 241 and IEEE 242.

1. Transformers:
   a. ANSI C57.12.10.
   b. ANSI C57.12.22.
   c. ANSI C57.12.40.
   d. IEEE C57.12.00.
   e. IEEE C57.96.
2. Medium-Voltage Circuit Breakers: IEEE C37.010.
3. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1.
4. Low-Voltage Fuses: IEEE C37.46.

E. Study Report:

1. Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.
2. Show interrupting (5-cycle) and time-delayed currents (6 cycles and above) on medium- voltage breakers as needed to set relays and assess the sensitivity of overcurrent relays.

F. Equipment Evaluation Report:

1. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
2. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
3. 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.

3.04 COORDINATION STUDY

A. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.

1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.
2. Calculate the maximum and minimum interrupting duty (5 cycles to 2 seconds) short- circuit currents.
3. Calculate the maximum and minimum ground-fault currents.

B. Comply with IEEE 241 recommendations for fault currents and time intervals.

C. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:
   a. Inrush current when first energized.
   b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.

c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

D. Motors served by voltages more than 600 V shall be protected according to IEEE 620.

E. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

F. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:

1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
   a. Device tag.
   b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
   c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
   d. Fuse-current rating and type.
   e. Ground-fault relay-pickup and time-delay settings.

2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
   a. Device tag.
   b. Voltage and current ratio for curves.
   c. Three-phase and single-phase damage points for each transformer.
   d. No damage, melting, and clearing curves for fuses.
   e. Cable damage curves.
   f. Transformer inrush points.
   g. Maximum fault-current cutoff point.

G. Completed data sheets for setting of overcurrent protective devices.

3.05 ARC-FLASH HAZARD ANALYSIS

A. Perform an arc-flash hazard analysis using the approved software. The Arc-Flash Hazard Analysis shall be based on the IEEE Standard 1584-2002.

1. Arc Flash Boundary Calculation Tables to include, as a minimum, the following:
   a. Fault values (kA) for each bus and protective device arcing and bolted faults
   b. Arc Flash Boundary in inches for each piece of equipment
   c. Incendent energy (Calories/square cm) for each piece of equipment
   d. Required Hazard Risk Clothing Class Category

2. Include color coded legend and color coded labels identifying the PPE Hazard Risk Category for each piece of equipment for the purpose of being attached to the equipment.

END OF SECTION 16055

SECTION 16060
GROUNDING AND BONDING

1.00 GENERAL

1.01 SCOPE OF WORK

A. This Section includes methods and materials for grounding systems and equipment.
   1. Underground distribution grounding.
   2. Common ground bonding.

B. Type of electrical grounding and bonding work specified in this section includes the following: Solidly grounded.

C. Applications of electrical grounding and bonding work in this section includes the following:
   1. Building Steel
   2. Underground copper water piping.
   3. Electrical power systems.
   4. Grounding rods.
   5. Separately derived systems.
   6. Raceways.
   7. Service equipment.
   8. Enclosures.
   9. Equipment.
   10. Transformers.
   11. Area lighting fixtures.
   12. Distribution transformers.
   13. Switchboard.
   14. Ground Rings.

D. Refer to other Division 16 sections for wires/cables, electrical raceways, boxes and fittings, and wiring devices which are required in conjunction with electrical grounding and bonding work.

1.02 SUBMITTALS

A. Product Data and Plans showing dimensioned as-built locations of grounding features specified in Part 3 "Field Quality Control" Article, including the following:
   1. Test wells.
   2. Ground rods.
   3. Ground rings.
   4. Grounding arrangements and connections for separately derived systems.
   5. Grounding for sensitive electronic equipment.

B. Field quality-control test reports.

C. Operation and Maintenance Data: For grounding to include the following in emergency, operation, and maintenance manuals:
   1. Instructions for periodic testing and inspection of grounding features at test wells, and grounding connections for separately derived systems. Tests shall be to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not. Include recommended testing intervals.

D. Operation and Maintenance Data: For grounding to include the following in emergency, operation, and maintenance manuals:

1. Instructions for periodic testing and inspection of grounding features at test wells, and grounding connections for separately derived systems.

a. Tests shall be to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.

b. Include recommended testing intervals.

1.03 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Install grounding and bonding products of firms regularly engaged in the manufacture of these materials, including stranded cable, grounding rods, and bonding jumpers.

B. Electrical Code Compliance: Comply with the applicable State electrical code requirements of the authority having jurisdiction, and NEC as applicable to electrical grounding and bonding, pertaining to systems, circuits and equipment.

C. UL Compliance: Comply with applicable requirements of UL Standards No.'s 467, "Electrical Grounding and Bonding Equipment," and 869, "Electrical Service Equipment," pertaining to grounding and bonding of systems, circuits and equipment. In addition, comply with UL Standard 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors."

D. IEEE Compliance: Comply with applicable requirements of IEEE Standards 142 and 241 pertaining to electrical grounding.

2.00 PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with requirements, manufacturers offering grounding products which may be incorporated in the work include, but are not limited to, the following:

1. B Line Systems, Inc.
2. Burndy Corporation.
3. Crouse Hinds Div.
4. Cooper Industries.
5. Electrical Components Div.
6. Gould Inc.
7. Ideal Industries, Inc.
8. O Z/Gedney
9. Thomas & Betts Corp.
10. VFC, Inc.
11. Western Electric Co.

2.02 MATERIALS AND PRODUCTS

A. General: Except as otherwise indicated, provide electrical grounding and bonding systems indicated; with assembly of materials, including, but not limited to, cables/wires, connectors, solderless lug terminals, grounding rods, bonding jumpers, service arresters, and additional accessories needed for a complete installation.

B. Where more than one type component product meets indicated requirements, selection is Contractor's option.

C. Where materials or components are not indicated, provide products which comply with NEC and UL requirements and with established industry standards for those applications indicated. Products include: Conductors, Connectors and Connection Accessories, Grounding electrodes and connection accessories.

2.03 CONDUCTORS

A. Insulated Conductors: Solid green insulation with copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:
1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Grounding Bus: Rectangular bars of annealed copper, 1/4 by 2 inches high in cross section, unless otherwise indicated; with insulators.

2.04 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.05 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch in diameter by 10 feet long.

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 1216 mm (48 inches) long.

2. Backfill Material: Electrode manufacturer's recommended material.

2.06 ELECTRICAL GROUNDING CONNECTION ACCESSORIES

A. Provide electrical insulating tape, bonding straps, as recommended by accessories manufacturers for type service indicated.

3.00 EXECUTION

3.01 APPLICATIONS

A. Underground Grounding Conductors: Install bare stranded-copper conductor, No. 3/0 AWG minimum.
1. Bury at least 24 inches below grade.
2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

B. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

C. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
1. Install bus on insulated spacers 1 inch, minimum, from wall 6 inches above finished floor, unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and 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.

3.02 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.03 EQUIPMENT GROUNDING

A. Install green insulated equipment grounding conductors with all feeders and branch circuits. The raceway system shall not be relied on for ground continuity.

B. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate

insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

C. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

D. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

E. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
   1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 8 mm x 50xmm x 610 mm (1/4-by-2-by-24-inch) grounding bus, using irreversible connectors.
   2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

F. Metal 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.

G. Boxes with concentric, eccentric or over-sized knockouts shall be provided with bonding bushings and jumpers. The jumper shall be sized per NEC Table 250-122 and lugged to the box.

3.04 INSTALLATION

A. General: Install electrical grounding and bonding systems as indicated, in accordance with manufacturer's instructions and applicable portions of NEC, NECA's "Standard of Installation," and in accordance with recognized industry practices to ensure that products comply with requirements.

B. Install grounding systems as designed and submit certified test report on grounding system.

C. Coordinate with other electrical work as necessary to interface installation of electrical grounding and bonding system work with other work.
   1. Where tests show resistance to ground is over 25 ohms, take appropriate action to reduce resistance to 25 ohms, or less, by driving additional ground rods. A copy of the ground resistance test report shall be sent to the Construction Manager's office, to the attention of the "review section".
   2. Retest grounding system to demonstrate compliance.
   3. Provide written certified testing report indicating resistance to ground value.

D. Ground electrical service system neutral at service entrance equipment to grounding rod(s), grounded copper water pipe, and foundation building steel.

E. Ground each separately derived system neutral to an effectively grounded copper water pipe.

F. Connect together system neutral, service equipment enclosures, exposed noncurrent carrying metal parts of electrical equipment, metal raceway systems, grounding conductor in raceways and cables, receptacle ground connectors, and cold water systems.

G. Provide ground clamps for grounding conductors to underground grounding rods.

H. Provide a separate, insulated equipment grounding conductor from each device to ground buses in panelboards. Terminate each end on a grounding lug, bus, or insulated grounding bushing.

I. Provide grounding system per the Drawings and Article 250 of the NEC. Provide green equipment grounding conductor for all electrical raceways.

J. Connect grounding electrode conductors to copper water pipe using a suitable grounding clamp as indicated on the Drawings. Provide conduit grounding hubs and water pipe ground clamps as required.

K. Use minimum #1/0 AWG copper conductor for communications service grounding conductor. Leave 2700 mm (9 feet) of slack conductor at terminal board.

L. Provide insulated grounding bushings on all service entrance conduit terminations up to the first overcurrent protection device.

M. Connect grounding electrode conductors to 1 inch diameter, or greater, metallic cold water pipe using a suitably sized ground clamp.

N. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torquing requirements are not indicated, tighten connections to comply with tightening torque values specified in UL 486A to assure permanent and effective grounding.

O. Apply corrosion resistant finish to field connections, buried metallic grounding and bonding products, and places where factory applied protective coatings have been destroyed, which are subjected to corrosive action.

P. Provide clamp on connectors on clean metal contact surfaces, to ensure electrical conductivity and circuit integrity.

Q. Transformer housing, cable shields, primary and secondary neutrals shall be connected to a driven copper ground having a maximum resistance of 25 ohms using No. 2 AWG green insulated Type "THW" or "THHN"/"THWN" stranded copper conductor. Primary neutral conductor shall be unbroken to transformer primary neutral bushing, and thereafter grounded as indicated on the Drawings.

R. 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.

S. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

T. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade, unless otherwise indicated.
   1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.

U. 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 metal structure, provided the building frame is effectively grounded.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
   3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

V. 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, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
   2. Water Meter Piping: Use braided-type bonding meters. Connect to pipe with a bolted connector
   3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

W. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

X. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

Y. 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 area or item indicated.
   1. Install tinned-copper conductor not less than No. 3/0 AWG for ground ring and for taps to building steel.
   2. Bury ground ring not less than 5 feet from building foundation.

3.05 FIELD QUALITY CONTROL

A. Examination:
   1. Examine areas and conditions under which electrical grounding and bonding connections are to be made and notify Engineer in writing of conditions detrimental to proper completion of work.
   2. Do not proceed with work until unsatisfactory conditions have been corrected.

B. Perform the following tests and inspections and prepare test reports:
   1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
   2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Make tests at ground rods before any conductors are connected.
      a. Measure ground resistance not less 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.
   3. 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.

C. Excessive Ground Resistance: If resistance to ground exceeds specified values, additional ground rods shall be driven to reduce the resistance to that specified. Compliance shall be demonstrated by retesting.

D. A copy of the ground resistance test report shall be sent to the Owner's representative.

END OF SECTION 16060

SECTION 16062
LIGHTNING PROTECTION

1.00 GENERAL

1.01 SUMMARY

This Section includes lightning protection for buildings.
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1.02 DEFINITIONS

A. LPI: Lightning Protection Institute.
B. NRTL: National recognized testing laboratory.

1.03 SUBMITTALS

A. Product Data: For air terminals and mounting accessories.
B. Shop Drawings: Detail lightning protection system, including air-terminal locations, conductor routing and connections, and bonding and grounding provisions. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.
C. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include data on listing or certification by an NRTL or LPI.
D. Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the single-ply membrane roofing material.
E. Field inspection reports indicating compliance with specified requirements.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who is an NRTL or who is certified by LPI as a Master Installer/Designer.

B. Listing and Labeling: As defined in NFPA 780, "Definitions" Article.

1.05 COORDINATION

A. A.Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.
B. charges and coordination with power and telephone companies and other authorities or persons involved in the procedures.
C. Preparation of as-built plans and drawings.
D. Furnish and install a complete grounding system.
E. If anything has been omitted of any item of works or materials, usually furnished, which are necessary for the completion of the electrical works as outlined herein before, then such items shall be and are hereby included in this division of the work.

2.00 PRODUCTS

2.01 GENERAL

Where specifications of any type of material or equipment are in question, such materials shall conform to the standard specifications set by the following:

A. U.S. UNDERWRITERS LABORATORIES
B. U.S. NATIONAL BOARD OF FIRE UNDERWRITERS
C. NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
D. INSULATED POWER CABLE
E. AMERICAN STANDARDS ASSOCIATION
F. BUREAU OF STANDARDS, DEPARTMENT OF TRADE
G. PHILIPPINE NATIONAL STANDARDS

2.02 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. Comply with UL 96.
B. Roof-Mounting Air Terminals: NFPA Class II, copper, solid, unless otherwise indicated.
   1. Single-Membrane, Roof-Mounting Air Terminals: Designed for single-membrane roof materials.
C. Stack-Mounting Air Terminals: Solid copper.
D. Ground Rods, Ground Loop Conductors, and Concrete-Encased Electrodes: Comply with Division 16 Section "Grounding and Bonding" and with standards referenced in this Section.
E. Down Lead Conductor: Routed in schedule 40 PVC conduit. (Building steel will not be used for down conductors).

3.00 EXECUTION

3.01 INSTALLATION

A. Install lightning protection components and systems according to UL 96A and applicable requirements of NFPA 780.
B. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops.
C. Conceal the following conductors:
   1. System conductors.
   2. Down conductors.
   3. Interior conductors.
   4. Conductors within normal view from exterior locations at grade within 200 feet of building.
   5. Notify Architect at least 48 hours in advance of inspection before concealing lightning protection components.
D. Cable Connections: Use approved exothermic-welded connections for all conductor splices and connections between conductors and other components, except those above single-ply membrane roofing.
E. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.
F. Bond extremities of vertical metal bodies exceeding 60 feet in length to lightning protection components.

G. A # 3/0 bare copper ground loop will be installed 30" below grade around the perimeter of the building tied into building steel at intervals not to exceed 50'.
   1. Bond ground terminals to ground loop at test wells.
   2. Bond grounded metal bodies on building within 12 feet of ground to loop.

3.02 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.03 FIELD QUALITY CONTROL

A. UL Inspection: Provide inspections as required to obtain a UL Master Label for system.

END OF SECTION 16062

SECTION 16065
DIVISION OF WORK

1.00 GENERAL

1.01 SCOPE OF WORK

A. This Section delineates the division of work between Division 16 and other Divisions providing equipment.

B. Specific work to be done under Division 16 is hereinafter listed or described. The Division providing the equipment shall perform all other electrical work necessary for the operation of that Division's equipment.

C. All individual variable frequency drives, motor starters, and disconnects for other Division's equipment (fans, pumps, kitchen, elevator etc.) shall be furnished and installed by that contractor unless indicated as part of a motor control center. Motor starters for mechanical equipment provided in a motor control center shall be furnished and installed by the electrical contractor.

D. The electrical contractor shall be responsible for power wiring and conduit up to a termination point consisting of a junction box, trough, variable frequency drive, starter, or disconnect switch. T he electrical contractor shall also be responsible for line side terminations. Wiring and conduit from that termination point to the equipment, including final terminations, shall be provided by the contractor providing the equipment.

E. Duct smoke detectors shall be provided and wired by Division 16, installed by Division 15. Fire alarm AHU shut down circuits shall be wired from the fire alarm control panel to a termination point, adjacent to the fire alarm control panel, under Division 16. AHU control wiring from the termination point to the equipment will be under Division 15.

F. All relays, actuators, timers, 7-day clocks, alternators, pressure, vacuum, float, flow, pneumatic-electric and electric-pneumatic switches, aquastats, freezestats, line and low voltage thermostats, solenoid valves, thermals, remote selector switches, remote push-button stations, emergency break-glass stations, interlocking, disconnect switches beyond termination point, and other appurtenances associated with equipment furnished under Division 15 shall be furnished, installed, and wired by Division 15.

G. All wiring required for Controls and Instrumentation not indicated on the Drawings shall be furnished and installed by Division 15.

H. Roof exhaust fans with built-in disconnects under Division 15 shall be wired under Division 16 to the line side of the disconnect switch. A disconnect switch shall be provided under Division 15 if the fan is not provided with a built-in disconnect switch. In this case, wiring from the switch to the fan shall be under Division 15.

I. All sprinkler flow and tamper switches will be furnished and installed under Division 15 and wired under Division 16.

1.02 DIVISION OF WORK – DIVISION 16 AND OTHER DIVISIONS

A. Each Contractor is responsible for fire stopping their own floor and wall penetrations. Install sealant (including forming, packing, and other accessory materials) to fill openings around electrical items penetrating floors and walls and to provide fire-stops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs. Comply with installation requirements established by testing and inspecting agency. Provide UL listed mechanical fire stop or UL classified foam sealant.

B. Where electrical wiring, conduit, or any other electrical equipment or components is required by trades other than covered by Division 16, specifications for that section shall refer to the same wiring materials and methods as specified under Division 16. There will be no exceptions.

2.00 PRODUCTS (Not Used)

3.00 EXECUTION (Not Used)

END OF SECTION 16065

SECTION 16070
ELECTRICAL TESTING

1.00 GENERAL

1.01 DESCRIPTION

A. Section 16070 is in addition to all other checklists, testing, and any pre-commissioning requirements. This section (16070) does not exempt contractual requirements to perform other tests, etc. throughout each and every Division 16000 Specification section.

B. This Section includes general requirements for electrical field testing and inspecting. Without exception, the Contractor is responsible and bid price includes all testing referenced within this section and all other Div. 16000 sections. General requirements include the following:
   1. Qualifications of testing agencies and their personnel.
   2. Suitability of test equipment.
   3. Calibration of test instruments.
   4. Coordination requirements for testing and inspecting.
   5. Reporting requirements for testing and inspecting.

C. Include in testing, ground, resistance, conducting, and torque testing on all newly installed feeders. This applies to all feeders to panelboards and individual pieces of HVAC equipment.

D. Test shall be from and including lugs of originating source to terminal lugs @ equipment listed above.
   1. Test ground continuity throughout circuit.
   2. Test resistivity of insulation for each feeder conductor.
   3. Test and verify conductance per dards, wire manufacturer's recommendations, and applicable U.L. Standards. Check torque at all lugs. Retorque where appropriate ft. pound valve at termination does not meet cable manufacturer's specifications and U.L. Standards for tested cable.

E. The Contractor shall record in writing the results of each test parameter at each feeder and submit to both the Owner and the Engineer prior to beginning any work in subject panelboard.

1.02 QUALITY ASSURANCE

A. If a group of tests are specified to be performed by an independent testing agency:
   1. Independent Testing Agencies: Independent of manufacturers, suppliers, installers of components to be tested or inspected.
   2. Testing Agency's Field Supervisor for Power Component Testing: Person currently certified by the International Electrical Testing Association or the National Institute forCertification in Engineering Technologies to supervise on-site testing specified in Division 16 switchboard, generator, automatic transfer switches, panelboards Sections.

B. Test Equipment Suitability: Comply with NETA ATS, Section 5.2.

C. Test Equipment Calibration: Comply with NETA ATS, Section 5.3.

2.00 PRODUCTS (Not Used)

3.00 EXECUTION

3.01 GENERAL TESTS AND INSPECTIONS

A. If a group of tests is specified to be performed by an independent testing agency, prepare systems, equipment, and components for tests and inspections, and perform preliminary tests to ensure that systems, equipment, and components are ready for independent agency testing. Include the following minimum preparations for electrical system testing as appropriate:
   1. Perform insulation-resistance tests.
   2. Perform continuity tests.
   3. Perform rotation test (for motors to be tested).
   4. Provide a stable source of single-phase, 208/120-V electrical power for test instrumentation at each test location.

B. Test and Inspection Reports: In addition to requirements specified elsewhere, report the following:
   1. Manufacturer's written testing and inspecting instructions.
   2. Calibration and adjustment settings of adjustable and interchangeable devices involved in tests.
   3. Tabulation of expected measurement results made before measurements.
   4. Tabulation of "as-found" and "as-left" measurement and observation results.

END OF SECTION 16070

SECTION 16073
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

1.00 GENERAL

1.01 SCOPE OF WORK

A. This Section includes the following:
   1. Hangers and supports for electrical equipment and systems.
   2. Construction requirements for concrete bases.

B. Related Sections include the following:
   1. Division 16 Section "Vibration and Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

C. Extent of supports, anchors, sleeves and seals is indicated by the Drawings and Schedules and/or specified in other Division 16 sections.

D. Types of supports, anchors, sleeves and seals specified in this section include the following:
   1. Clevis hangers.
   2. I-beam clamps.
   3. One-hole conduit straps.
   4. Round steel rods.
   5. Lead expansion anchors.
   6. Toggle bolts.
   7. Wall and floor seals.

E. Supports, anchors, sleeves and seals furnished as part of factory-fabricated equipment

1.02 PERFORMANCE REQUIREMENTS

A. Delegated design supports for multiple raceways, including comprehensive engineering analtsis by a qualified professional engineer, suing performance requirements and design criteria indicated.

B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.03 SUBMITTALS

A. Product Data: For the following:
   1. Steel slotted support systems.
   2. Nonmetallic slotted support systems.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
   1. Trapeze hangers. Include Product Data for components.
   2. Steel slotted channel systems. Include Product Data for components.
   3. Nonmetallic slotted channel systems. Include Product Data for components.
   4. Equipment supports.

C. Welding Certificates.

2.00 PRODUCTS (Not Used)

3.00 EXECUTION

3.01 APPLICATION

A. Note: products and assemblies to comply with NECA 1 and NEA 101 for hangers and supports. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

B. 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 single-bolt conduit clamps.

C. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-12/ inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports,

3.02 SUPPORT INSTALLATION

A. Raceway Support Methods (RMC): In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structural members, as permitted in NFPA 70.

B. 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 .

C. 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:

3.03 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000 psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 3 Section "Cast-in-Place Concrete."

C. Anchor equipment to concrete base. Setting drawigns, templates, diagrams, instructions and directions furnished with items to be embedded. Use supported equipment manufacturer’s nstall anchor bolts to elevations required for proper attachment to supported equipment.

3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

END OF SECTION 16073

SECTION 16075
ELECTRICAL IDENTIFICATION

1.00 GENERAL

1.01 SCOPE OF WORK

A. This Section includes the following:
   1. Identification for raceway and metal-clad cable.
   2. Identification for conductors and communication and control cable.
   3. Underground-line warning tape.
   4. Warning labels and signs.
   5. Instruction signs.
   6. Equipment identification labels.
   7. Miscellaneous identification products.

1.02 SUBMITTALS

A. Product Data: For each electrical identification product indicated.
B. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.
C Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

1.03 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and ANSI C2, and NFPA 70.
B. Manufacturers: Firms regularly engaged in manufacture of electrical identification products of types required.
C. Third Party Agency Compliance: Provide products which have been listed and/or labeled by a third party agency accredited by the NCBCC to label electrical and mechanical equipment.
D. NEMA Compliance: Comply with applicable requirements of NEMA Std No's. WC-1 and WC-2 pertaining to identification of power and control conductors.

1.04 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
C. Coordinate installation of identifying devices with location of access panels and doors.
D. Install identifying devices before installing acoustical ceilings and similar concealment.

2.00 PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with requirements, provide electrical identification products of one of the following: Brady, W.H. Co.; Ideal Industries, Inc.; Seton Nameplate Co.
B. Submit nameplate information, including proposed wording for all phenolic nameplate.

2.02 JUNCTION BOX AND COVER COLORS

A. Junction boxes and covers will be spray painted prior to installation with the following colors:
   1. Blue surface for 120/208 volt equipment, with panel and circuit numbers identified with permanent markers.
   2. Black surface for 277/480 volt equipment, with panel and circuit numbers identified with permanent markers.
   3. Bright red surface for all equipment related to fire alarm system.
   4. Dark red (burgundy) for all equipment related to security.
   5. Green for all equipment related to emergency systems.
   6. Orange for all equipment related to telephone systems.
   7. Brown for all equipment related to data systems.
   8. White for all equipment related to paging systems.
   9. Purple for all equipment related to TV systems.

2.03 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

2.04 UNDERGROUND-LINE WARNING TAPE

A. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.
   1. Not less than 6 inches wide by 4 mils thick.
   2. Compounded for permanent direct-burial service.
   3. Embedded continuous metallic strip or core.
   4. Printed legend shall indicate type of underground line.

B. Cable/Conductor Identification Bands:
   1. General: Provide manufacturer's standard vinyl-cloth self-adhesive cable/conductor markers of wrap-around type, either pre-numbered plastic coated type, or write-on type with clear plastic self-adhesive cover flap; numbered to show circuit identification.

2.05 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 7 by 10 inches.

C. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 10 by 14 inches.

D. Warning label and sign shall include, but are not limited to, the following legends:
   1. Multiple Power Source Warning:
      "DANGER - ELECTRICAL SHOCK HAZARD –
      EQUIPMENT HAS MULTIPLE POWER SOURCES."
   2. Workspace Clearance Warning:
      "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.06 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. in. and 1/8 inch thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.07 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength: 50 lb (22.6 kg), minimum.
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.

B. Paint: Paint materials and application requirements are specified in Division 9 painting Sections.
1. Exterior Concrete, Stucco, and Masonry (Other Than Concrete Unit Masonry):
   a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
      1) Primer: Exterior concrete and masonry primer.
      2) Finish Coats: Exterior semigloss acrylic enamel.
2. Exterior Concrete Unit Masonry:
   a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a block filler.
      1) Block Filler: Concrete unit masonry block filler.
      2) Finish Coats: Exterior semigloss acrylic enamel.
3. Exterior Ferrous Metal:
   a. Semigloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
      1) Primer: Exterior ferrous-metal primer.
      2) Finish Coats: Exterior semigloss alkyd enamel.
4. Exterior Zinc-Coated Metal (except Raceways):
   a. Semigloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
      1) Primer: Exterior zinc-coated metal primer.
      2) Finish Coats: Exterior semigloss alkyd enamel.
5. Interior Concrete and Masonry (Other Than Concrete Unit Masonry):
   a. Semigloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
      1) Primer: Interior concrete and masonry primer.
      2) Finish Coats: Interior semigloss alkyd enamel.
6. Interior Concrete Unit Masonry:
   a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a block filler.
      1) Block Filler: Concrete unit masonry block filler.
      2) Finish Coats: Interior semigloss acrylic enamel.
7. Interior Gypsum Board:
   a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
      1) Primer: Interior gypsum board primer.
      2) Finish Coats: Interior semigloss acrylic enamel.
8. Interior Ferrous Metal:
   a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.

1) Primer: Interior ferrous-metal primer.
2) Finish Coats: Interior semigloss acrylic enamel.

9. Interior Zinc-Coated Metal (except Raceways):
   a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
      1) Primer: Interior zinc-coated metal primer.
      2) Finish Coats: Interior semigloss acrylic enamel.

C. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws (if the screw's sharp end is protected); otherwise rivets shall be used.

2.08 EQUIPMENT INDENTIFICATION LABELS

A. General: Provide engraving stock melamine plastic laminate, in sizes and thicknesses indicated, engraved with engraver's standard letter style 1/2" (minimum) in height on 1-1/2" high sign (2" high where 2 lines are required), and with wording indicated, punched for mechanical fastening. Color Coding as follows.

SYSTEM:	COLOR CODING:
480Y/277V	Black Surface
208Y/120V	Blue Surface
Fire Alarm System	Bright Red Surface
Security System	Dark Red Surface
Standby System	Green Surface
Telephone System	Orange Surface
Data System	Brown Surface
Television System	Purple Surface
Paging System	White Surface

Note: All name tags shall have white core, except paging will have black core.

B. All Empty conduit runs and conduit with conductors for future use shall be identified for use and shall indicate where they terminate. Identification shall be by tags with string or wire attached to conduit or outlet.
C. All outlet boxes, junction boxes and pull boxes shall have their covers and exterior visible surfaces painted with color to match the surface color scheme.
D. Thickness: 1/16", for units up to 20 sq. in. or 8" length; 1/8" for larger units.
F. Fasteners: Self tapping stainless steel screws or rivets.
G. Lettering and Graphics:
H. General: Coordinate names and other designations used in electrical identification work, with corresponding designations shown, specified or scheduled.
I. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturer or as required for proper identification and operation/maintenance of electrical systems and equipment.

3.00 EXECUTION

3.01 APPLICATION

A. Raceways and Duct Banks More Than 600 V Concealed within Buildings: 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 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 and Metal-Clad Cables More Than 600 V: Identify with "DANGER-HIGH VOLTAGE" in black letters at least 2 inches (50 mm) high, with self-adhesive vinyl labels. Repeat legend at 10-foot (3-m) maximum intervals.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A: Identify with self-adhesive vinyl label.

D. Power-Circuit Conductor Identification: For primary and secondary conductors No.1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes use color-coding conductor tape. Identify source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.

E. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data 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.

F. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply baked-enamel warning signs. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.
   1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
      a. Power transfer switches.
      b. Controls with external control power connections.
   2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

G. Instruction Signs:
   1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
   2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for power transfer and load shedding.
   3. Equipment to Be Labeled:
      a. Panelboards, electrical cabinets, and enclosures.

b. Access doors and panels for concealed electrical items.
c. Electrical switchgear and switchboards.
d. Transformers.
e. Electrical substations.
f. Emergency system boxes and enclosures.
g. Motor-control centers.
h. Disconnect switches.
i. Enclosed circuit breakers.
j. Motor starters.
k. Push-button stations.
l. Power transfer equipment.
m. Contactors.
n. Remote-controlled switches, dimmer modules, and control devices.
o. Battery inverter units.
p. Battery racks.
q. Power-generating units.
r. Voice and data cable terminal equipment.
s. Master clock and program equipment.
t. Intercommunication and call system master and staff stations.
u. Television/audio components, racks, and controls.
v. Fire-alarm control panel and annunciators.
w. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks.
x. Monitoring and control equipment.
y. Uninterruptible power supply equipment.
z. Terminals, racks, and patch panels for voice and data communication and for signal and control functions.

3.02 CONDUIT IDENTIFICATION

A. Underground Cable Identification:
1. Install line marker for all buried conduits.

3.03 CABLE/CONDUCTOR IDENTIFICATION

A. General: Apply cable/conductor identification, including feeder number, on each cable/conductor in each box/enclosure/cabinet where wires of more than one circuit or communication/signal system are present, except where another form of identification (such as color-coded conductors) is provided.

B. Match identification with marking system used in panelboards, shop drawings, contract documents, and similar previously established identification for project's electrical work.

C. General: Wherever reasonably required to ensure safe and efficient operation and maintenance of electrical systems, and electrically connected mechanical systems and general systems and equipment, including prevention of misuse of electrical facilities by unauthorized personnel, install mechanically fastened plastic signs or similar equivalent identification, instruction or warnings on switches, outlets and other controls and devices.

D. Where instructions or explanations are needed, provide plasticized tags with clearly written messages adequate for intended purposes.

3.04 EQUIPMEN T/ SYSTEM IDENTIFICATION

A. Provide text matching terminology and numbering of the contract documents and shop drawings.

B. Install signs at locations for best convenience of viewing without interference with operation and maintenance of equipment. Secure to substrate with fasteners, except use adhesive where fasteners should not or cannot penetrate substrate.

C. Verify identity of each item before installing identification products.

D. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. System Identification Color Banding for Raceways and Cables: Each color 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.

G. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors.

1. Color shall be field applied for sizes larger than No. 10 AWG, for conductors No. 10 AWG and smaller the conductor insulation will be colored.
2. Colors for 208/120-V Circuits:
   a. Phase A: Black. b. Phase B: Red.
   c. Phase C: Blue. d. Neutral: White. e. Ground: Green.
3. Colors for 480/277-V Circuits:
   a. Phase A: Brown. b. Phase B: Orange. c . Phase C: Yellow.
   d. Neutral: Natural grey. e. Ground: Green.
4. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

H. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

I. All outlet boxes, junction boxes and pull boxes shall have their covers and exterior visible surfaces painted with colors to match the surface color scheme outlined above. This includes covers on boxes above lift-out and other type accessible ceilings.

END OF SECTION 16075

SECTION 16100
BASIC ELECTRICAL MATERIALS AND METHODS

1.00 GENERAL

1.01 GENERAL DESCRIPTION

All electrical works for this project shall be governed by the provisions of the latest edition of the Philippine Electrical Code, rules and regulations of Local Authorities that have jurisdiction over the project and policies of electric and communication utility companies in the locality.

The plans and specifications are complementary, and what is called for in one shall be taken as called for in both.

The General Conditions and Provisions of the Civil Works Contract not in conflict with the plans and specifications form part of this section of the specifications.

1.02 SITE VISIT

The Contractor is advised to visit the site to ascertain for himself the prevailing local conditions there at and to check the existing line facilities of local power and communication companies. Also, to investigate other pertinent things that may affect his work. It shall be presumed that he had done this before preparing his proposal and no subsequent claim on the ground of inadequate or inaccurate information will be entertained.

1.03 SCOPE OF WORK OF THE CONTRACTOR

The work of the Contractor includes supervision, labor, equipment and materials, and to perform all electrical operations in connection with the electrical system shown on the plans, and their tests and inspection complete and in accordance with these specifications and plans and subject to the terms and conditions of the contract. Any equipment, materials, or works not shown on the plans but mentioned in the specifications, or vice-versa, shall be furnished and installed by the Contractor.

The following are the scope of work of the Contractor:

A. Install Owner-supplied transformers at locations indicated in the plans. Provide concrete base mounting pads.
B. Furnish and install Generator Sets. Provide resilient mounting pads on concrete base.
C. Furnish and install power service entrance including related concreting and civil works, such as excavation / backfilling and concrete encasement.
D. Furnish and install a complete roughing-in and wiring systems for lighting and power including feeders, branch circuits and taps.
E. Furnish and install all lighting fixtures, wiring devices and necessary wiring gutters and boxes.
F. Furnish and install motor wiring inclusive from overcurrent device to motor terminals except those specified to be done by other trades.
G. Furnish and install wiring and conduits for pump and electronic control motors of mini-irrigation system inclusive from overcurrent device to motor terminals except those specified to be done by other trades.

H. Furnish and install service entrance PVC conduit for incoming telephone service including related concreting and civil works.
I. Furnish and install complete telephone and public address/paging systems, wiring, outlets, telephone terminal cabinets, terminal blocks, wiring accessories, devices and all terminations.
J. Furnish and install a complete fire alarm system including wiring, control panel, alarm stations, bell stations, smoke detectors and heat detectors.
K. Furnish and install panelboards and enclosed circuit breakers as required.
L. Complete testing of all electrical and auxiliary systems.
M. Painting of all panelboards and enclosures.
N. Application of electric power service and telephone service connections including preparation of all necessary plans, forms and related documents, payment of government fees and charges and coordination with power and telephone companies and other authorities or persons involved in the procedures.
O. Preparation of as-built plans and drawings.
P. Furnish and install a complete grounding system.
Q. If anything has been omitted of any item of works or materials, usually furnished, which are necessary for the completion of the electrical works as outlined herein before, then such items shall be and are hereby included in this division of the work.

1.04 WORK NOT INCLUDED

A. Furnishing and installation of the kilo-watt hour meter which is to be supplied by others.
B. Furnishing of transformer which are to be supplied by Owner.

1.05 EXCAVATION AND BACKFILL

The Contractor shall be responsible for excavation to layout his electrical conduit. Excavation shall be such as to provide a uniform bearing for the conduit and shall be filled with gravel to grade.

1.06 CUTTING AND PATCHING

The Contractor shall furnish sketches to the General Contractor showing the location and sizes of all openings, chases, sleeves and inserts. He shall be responsible for the cost of cutting and patching where any electrical items were not installed, incorrectly sized or located. No structural members shall b cut without the consent and proper direction from the Architect. All patching shall be performed in a neat and workmanlike manner acceptable to the Architect.

1.07 SUBCONTRACTING

whole or any part of the work without the written consent of the Owner. The Contractor shall be responsible for any work carried out by any subcontractor as if he himself were undertaking the job.

1.08 WORKMANSHIP

The Contractor shall execute all works in a neat and workmanlike manner and shall do all necessary works whether or not it is clearly specified in the plans and these specifications. All

works shall be done in accordance with the best practices employed in modern electrical installations.

The Contractor shall employ only competent and efficient workmen and shall, upon written request of the Architect, discharge or otherwise remove from work any employee who, in the opinion of the Architect, is careless, incompetent, an obstruction to the progress of the work, acts contrary to instructions or conducts himself improperly.

1.09 STANDARD OF MATERIALS

All materials shall be new and must conform with the technical specifications. They shall be standard products of reputable manufacturers and shall bear its name.

All materials shall be subject to the approval of the Architect. This approval shall not relieve the Contractor of the responsibility of inspecting such materials for defects and non-conformance with the specifications.

Where the technical specifications or the drawings give the name of the manufacturer and/or catalog number of a material, it is given as guide as to the size, strength, quality or class of the material desired and shall be interpreted to mean that the item or another fully equal is suitable for the service intended. Substitution shall be subject to prior written approval of the Architect.

The apparent silence of the specifications and drawings as to any detail or apparent omission from them of a detailed description concerning any material shall be regarded to mean that only materials of first class quality shall be used.

1.10 REMOVAL OF DEFECTIVE OR UNAUTHORIZED WORK

Any defective work due to poor workmanship, defective materials, damaged through carelessness or any other cause, found to exist prior to acceptance of or final payment for the work shall be removed immediately and replaced by work and material which shall conform to these specifications or, otherwise, remedied in an acceptable manner. This clause shall have effect regardless of the fact that the work may have been done within the full knowledge of the Architect.

All materials not conforming to the requirements of the technical specifications shall be considered as defective.

No defective materials, the defect of which has been subsequently corrected, shall be used unless approval has been given by the Architect.

1.11 CONFORMITY WITH PLANS AND ALLOWABLE DEVIATIONS

These specifications and drawings indicate the general layout of the system and the Contractor shall be responsible for the proper installation of the system without substantial alterations or modifications. Whenever departures from the specifications and the drawings become inevitable due to field condition of exigencies of construction, details of proposed departures shall be submitted without delay to the Architect for approval.

1.12 COORDINATION WITH OTHER CONTRACTORS

The Contractor shall familiarize himself with the specifications and drawings of the Civil Works and those works of the specialty trades to avoid conflict with their work. Whenever conflict with the works of other trades are identified or pinpointed, this should be brought to the attention of the Architect immediately for proper disposition and coordination to arrive at the best solution.

1.13 INJURY TO PERSONS OR DAMAGE TO PROPERTY

The Contractor shall be responsible for all injuries to persons and damage to property caused by his work or by his workmen and shall be liable for any claim against the Owner on account of such injury and/or damage. Likewise, he shall be liable to damages and loss of Owner's property caused by inclement weather or theft due to his defective work, negligence or carelessness of his men. Should the Contractor cause damage to the works of any other contractor, he should settle the matter between them and free the Owner from any claim on account of such damage.

1.14 SUSPENSION OR DELAYS

The Contractor shall not suspend or fail to make progress in his work without justifiable cause. In the event of continuous delay or suspension of the work still persists despite a written complaint, at the Owner shall have the right to take over the work and all materials in the site and take the necessary steps to have the work completed by others.

1.15 INSPECTION AND TEST

The Architect, or his representative, shall be allowed access to all parts of the work at all times and shall be furnished information and assistance by the Contractor to conduct a detailed inspection test. The cost of such inspection and test shall be borne by the Contractor.

The Contractor shall conduct the following tests, where applicable, on all electrical conductors and equipment installed in the presence of the Owner or his duly authorized representative.

A. ground resistance test
B. insulation resistance test
C. continuity test
D. voltage level test
E. phase relationship

The Contractor shall also check circuit connection at panelboards, and see to it that all single phase circuits are connected at panelboards, and see to it that all single phase circuits are connected to phase as shown in the load schedule.

All reports must be formal, typewritten and signed with the signatory properly identified.

All defects found during the tests shall be repaired immediately by the Contractor.

All tools, equipment and instruments needed to conduct the tests shall be on the account of the Contractor.

1.16 CLEANING UP

During the progress of the entire work, the Contractor shall keep clean the premises at all times by removing all dirt, debris, rubbish and waste materials caused by him in the performance of his work. He shall remove all tools, scaffoldings and surplus materials after completion and acceptance of the work.

1.17 LEAVING THE SITE

The Contractor shall not withdraw from the site until the whole electrical system is complete and in operating condition and ready for use by the Owner.

1.18 GUARANTEE

The Contractor shall leave the entire electrical work in proper working condition. He shall replace any defective work or materials furnished and installed by him without charge for labor and materials except those caused by ordinary wear and tear within one year from the date of acceptance of the project by the Owner or Architect.

1.19 PERMITS AND DUES

The Contractor shall secure all necessary permits at his own expense and pay all corresponding government fees and taxes.

The Contractor shall include in his work, without extra cost to the Owner or Architect, drawings (in addition to contract drawings and documents) and associated paper works as required by the electric and telephone companies and government authorities.

1.20 SHOP DRAWINGS

The Contractor shall submit five (5) copies of shop drawings to the Architect for approval within thirty (30) days after the award of the contract.

Shop drawings or brochures for all major electrical equipment, including service entrance equipment, lighting fixtures, panelboards, switches, wiring devices and plates and equipment of auxiliary systems shall be submitted for approval. All equipment shall be a standard product of an established manufacturer whether the manufacturer's name is specified or not.

The Contractor shall be able to submit sample fixtures when requested by the Owner or Architect. All materials and equipment installed without prior approval of the Architect shall be at the risk of subsequent rejection.

1.21 AS-BUILT DRAWINGS

The Contractor shall record all deviations made from approved construction plans during the progress of electrical construction and shall reflect the actual layout in the as-built plans. Upon completion of the project, the Contractor shall submit to the Architect two (2) complete sets of as-built plans signed and sealed by the Contractor's Professional Electrical Engineer. One (1) set of original tracing reproducible copy shall be submitted to the Owner.

1.22 INSPECTION AND CERTIFICATES

Upon completion of the entire installation, the approval of the Architect and Owner shall be secured. The Contractor shall obtain, at his own expense, a Certificate of Electrical Inspection from the government authorities having jurisdiction over the project and submit same to the Architect prior to final payment.

1.23 EQUIVALENTS

When materials or equipment are mentioned by name, they shall form the basis of the contract. If the name is not mentioned, the Contractor may, thru written request, recommend an equivalent subject to the approval of the Architect. Substitution of specified materials, if allowed or approved by the Architect, will credit the Owner of any savings so obtained from the difference in cost.

1.24 DETAILED BREAKDOWN OF ESTIMATE

The Contractor shall submit a detailed estimate on each listed electrical system along with the bid proposal.

2.00 PRODUCTS

2.01 GENERAL

Where specifications of any type of material or equipment are in question, such materials shall conform to the standard specifications set by the following:

A. U.S. UNDERWRITERS LABORATORIES
B. U.S. NATIONAL BOARD OF FIRE UNDERWRITERS
C. NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
D. INSULATED POWER CABLE
E. AMERICAN STANDARDS ASSOCIATION
F. BUREAU OF STANDARDS, DEPARTMENT OF TRADE
G. PHILIPPINE NATIONAL STANDARDS

2.02 TRANSFORMER

Refer to Section 01020 Summary of Materials and Finishes and the Electrical (E) Plans.

2.03 GENERATOR

Refer to Section 01020 Summary of Materials and Finishes and the Electrical (E) Plans.

2.04 CONDUITS

A. Rigid steel conduits (RSC): shall be hot dipped galvanized, standard weight pipes made of mild steel smooth circular bore. It shall be in standard length of 3.05 meters including coupling, reamed and threaded on each end.
B. Intermediate Metallic Conduit (IMC).

C. Non-metallic conduit (PVC): CS40 smooth wall non-metallic conduit conforming to Philippine National Standards No. 14 for PVC Pipes. Conduit shall be in standard length of 3.05 meters including coupling.

2.05 SWITCHES, PANELBOARDS AND CIRCUIT BREAKERS

A. Circuit Breakers
Molded case circuit breakers shall be Japan-made. No bracing on handles of single pole breakers shall be allowed in lieu of two- or three-pole types.

B. Metal Enclosures and Cabinets
Panelboard enclosures, telephone cabinets, bus bar gutters, pull boxes, and wire gutters for feeders shall be locally fabricated by reputable manufacturers.

C. Safety Switches:
1. All safety switches shall be rated as shown in the plans and shall be fusible type unless noted otherwise.
2. All safety switches rated at 60A and above shall be spring assisted.

2.06 WIRES AND CABLES

Wires and cables shall be insulated for 600 volts. Feeders, sub-feeders and branch circuit wires and cables shall be soft drawn copper, annealed and of 98% conductivity, type THWN.
All joints or splices for No. 8 or larger shall be made with a double indent mechanical compression connector. Branch circuit splices shall be soldered. A soldered joint shall be carefully soldered without use of acid. After the conductors have been made mechanically and electrically secured, the entire joint shall be covered with rubber and plastic tapes to make the insulation of the joint or splice equal to the original insulation of the conductor.

2.07 LIGHTING FIXTURES

For lighting fixtures, lamps and accessories, refer to Section 01020 Summary of Materials and Finishes.

2.08 WIRING DEVICES

The following wiring devices are for small appliances, receptacles and switches to control lights only. For other specific loads they shall be described accordingly.

A. Duplex convenience outlet, grounding type, 10A, 250V.
B. Single-pole switch with mounting strap and device plate cover, 15A, 300V.
C. Two single-pole switch with mounting strap and device plate cover, 15A, 300V.
D. Three single-pole switch with mounting strap and device plate cover, 15A, 300V.
E. Three-way switch with mounting strap and device plate cover, 15A, 300V.
F. Special purpose outlet shall be as specified in the plans

2.09 COMMUNICATION SYSTEMS

A. TELEPHONE SYSTEM
Refer to Section 01020 Summary of Materials and Finishes. Telephone devices are owner supplied.

2.10 AUXILIARY SYSTEMS

All systems shall be as per plans.

A. Fire systems shall be as per plans.
B. Telephone and Intercom Systems shall be as per plans.

2.11 OTHERS

All other materials not mentioned herewith shall be one approved for the location and intended use and the best of its kind.

2.12 OPERATION AND MAINTENANCE

1. The Contractor shall furnish operation and maintenance manuals for each electrical and auxiliary systems and for each piece of equipment. Four (4) copies of the complete manual bound in hardback binders or an approved equivalent shall be provided to the Owner. One copy shall be provided to the Architect's office for future reference. The following identification shall be inscribed on the cover: the words "OPERATING AND MAINTENANCE MANUAL", the name and location of the project and the name of the Contractor. The manual shall include the names, address and the telephone numbers of each subcontractor supplying the equipment and systems, and of their local representatives. The manual shall have a table of contents with the tab sheets placed before instructions covering the subject. The instruction sheets shall be legible with large sheets of drawings folded in.
2. The manual shall include, but not limited to the following; a system layout showing circuits, devices and controls; wiring and control diagrams with data to explain detailed description of the function of each principal component of the system, the procedure for operating; shutdown instructions; installation instructions; maintenance instructions; test procedures; performance data; and parts list.
3. The parts list for equipment shall indicate the sources of supply, recommended spare parts, and life service organization which is reasonably convenient to the building site. The manual shall be complete in all respects for all equipment, controls and accessories provided.

3.00 EXECUTION

3.01 SERVICES

Power and telephone service entrances shall be in PVC pipes installed underground, in concrete encasement, from their designated tapping points to the building being served. Specifications for this type of installation as indicated in the site development plans shall be applied.

A. Secondary service voltage from transformer shall be : 220 volts, 3-phase, 3-wire, 60 Hz.
B. Telephone service entrance cable shall be supplied by the Contractor.

3.02 WIRING METHODS

A. Conduit runs for lighting, power and auxiliary branch layouts shall be in PVC pipes.

B. Exposed conduit runs which are subject to physical injury shall be in RSC pipes.
C. Underground conduit runs shall be in PVC pipes encased in concrete.

3.03 GROUNDING

The following shall be grounded in accordance with the drawings and the requirements of the Philippine Electrical Code.

A. Metal enclosures of panelboards and circuit breakers, wire gutters, pull boxes, junction boxes and utility boxes.
B. Non-current carrying metal parts of lighting fixtures, devices and motors.
C. Provide a continuous and effective equipment grounding system.

3.04 DISTRIBUTION FEEDERS

Feeder conductors and raceways shall be installed as shown on the plans and no changes in size shall be made without written consent from the Architect and Engineer. Feeder conductors shall be continuous without splices to its destination panelboards, circuit breakers and wire gutters.

3.05 BRANCH CIRCUITS

The plans indicate the general installation of all circuit wiring and outlets. Branch circuit raceways shall follow the line of shortest distance between connection points as practicable and in so far as the building condition would allow. However, exposed feeders and circuit raceways shall be installed following the building line. No wires of different circuits shall be inserted in one conduit. Where homerun for light and branch circuits exceeds thirty (30) meters, the next larger conductor size shall be used.

3.06 PANELBOARDS

Panelboards shall be fabricated from gauge no. 16 black iron (B.I.) sheet with epoxy primer and baked enamel paint finish. Doors shall be hinged with allen screw lock from the top to bottom. Front covers shall have a stainless push-to-open lock. Dead front covers shall only be removed after the front cover has been detached.

3.07 WIRE GUTTERS AND PULLBOXES

Common pullboxes and wire gutters shall be fabricated from gauge no. 16 B.I. sheet with epoxy primer and baked enamel paint finish. Cover shall have twist lock on corners and centers of edge.

3.08 OUTLET, SWITCH AND SPLICE BOXES

Power, lighting and auxiliary outlet boxes shall be fabricated from gauge no. 16 standard pressed steel or cast metal coated with red lead primer before installation.

3.09 RACEWAY SYSTEM

1. Conduit raceways and tubing shall not have more than four quarter bends in any continuous run. Where more than four (4) 90-degree bends become necessary, a pull box shall be installed to reduce the four (4) quarter bends into halves. Exposed conduits shall be run

parallel with or perpendicular to the building line. Exposed conduits shall be secured in place by means of approved supports, hangers or fastenings. Conduit supports shall be fastened to walls by means of bolts with expansion sleeves. The use of wood or lead plugs is not permitted. All conduit ends shall be firmly attached to cabinets or boxes by means of locknuts and bushings. Field bends shall not be allowed for rigid steel conduits larger than 20mm diameter. Threadless couplings and connectors used with the tubing shall be of concrete-tight type. No tubing smaller than 15mm diameter shall be used.

2. Exposed conduits shall be treated with red lead primer and finished with gray color paint. All field cut threads shall be painted with white lead.

END OF SECTION 16100

SECTION 16120
CONDUCTORS AND CABLES

1.00 GENERAL

1.01 SCOPE OF WORK

A. This Section includes the following:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.
3. Sleeves and sleeve seals for cables.

B. Related Sections include the following:

1. Division 16 Section "Voice and Data Communication Cabling" for cabling used for voice and data circuits.
2. Division 16 Section "Undercarpet Cables" for flat cables for undercarpet installations.

C. Extent of electrical wire and cable work is indicated by the Drawings and Schedules.

1. Types of electrical wire, cable, and connectors specified in this section include but are not limited to the following:

a. Split bolt connectors.
b. Wirenut connectors.
c. Copper conductors.
d. Fixture wires.
e. Service entrance cable.
f. Tap type connectors.

D. Applications of electrical wire, cable, and connectors required for this Project include but are not limited to the following:

1. For power distribution circuits.
2. For building lighting circuits.
3. For appliance and equipment circuits.
4. For motor branch circuits.

1.03 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.
B. NBR: Acrylonitrile-butadiene rubber.

1.04 SUBMITTALS

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

B. Qualification Data: For testing agency.

C. Field quality-control test reports.

D. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

E. Product data for each type of product specified.

1.05 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

C. Manufacturers: Firms regularly engaged in manufacture of electrical wire and cable products of types, sizes, and ratings required.

D. NEC Compliance: Comply with NEC requirements as applicable to construction, installation and color-coding of electrical wires and cables.

E. Third Party Agency Compliance: Provide products, which have been listed and/or labeled by a third party agency accredited by the NCBCC to label electrical and mechanical equipment as of August 1, 1991.

F. Delivery, Storage, and Handling:

1. Deliver wire and cable properly packaged in factory-fabricated type containers, or wound on NEMA-specified type wire and cable reels.

2. Store wire and cable in clean dry space in original containers. Protect products from weather, damaging fumes, construction debris and traffic.

3. Handle wire and cable carefully to avoid abrading, puncturing and tearing wire and cable insulation and sheathing. Ensure that dielectric resistance integrity of wires/cables is maintained.

1.06 COORDINATION

A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

2.00 PRODUCTS

2.01 CONDUCTORS AND CABLES

A. Manufacturers: Subject to compliance with requirements, provide products of one of the following (for each type of wire, cable, and connector):

1. Wire and Cable:

   a. American Insulated Wire Corp.
   b. Cablec Corp.
   c. General Cable Corp.
   d. Some Cable Corp.
   e. Southwire Company.
   f. Triangle PWC, Inc.
   g. Esset

2. Connectors:

   a. AMP, Inc.
   b. Appleton Electric Co.; Emerson Electric Co.
   c. Electrical Products Div.; Midland Ross Corp.
   d. Ideal Industries, Inc.
   e. 3M Company
   f. O Z/Gedney Co.
   g. Square D Company.
   h. Thomas & Betts Corp.

B. Copper Conductors: Comply with NEMA WC 70.Conductor Insulation:

C. Comply with NEMA WC 70 for Types THHN-THWN, XHHW.

D. Secondary Voltage Wires, Cables, and Connectors:

1. General: Provide electrical wires, cables, and connectors of manufacturer's standard materials, as indicated by published product information; designed and constructed as recommended by manufacturer, for a complete installation, and for application indicated. Provide copper conductors rated 600 Volts with conductivity of not less than 98% at 68o F.

2. Building Wires: Provide manufactured wires of sizes, ampacity ratings, and materials for applications and services indicated. Where not indicated, provide proper wire selection as determined by Contractor to comply with project's installation requirements, NEC and NEMA standards. Select from the following UL types, those wires with construction features which fulfill project requirements:

3. Type THW: For dry and wet locations; 600V, maximum operating temperature 75o C (167o F). Insulation, flame retardant, moisture and heat resistant, thermoplastic; conductor, annealed copper.

4. Type THWN: For dry and wet locations; 600V, maximum operating temperature 75o C (167o F). Insulation, flame retardant, moisture and heat resistant, thermoplastic; outer covering, nylon jacket; conductor, annealed copper.

5. Type XHHW (Underground Feeders): For dry and wet locations; 600V, maximum operating temperature 75o C (167o F). Insulation, moisture and heat resistant

rubber; outer covering, moisture resistant, flame retardant, nonmetallic covering; conductor, annealed copper.

6. Type THHN (Interior Branch Circuits): For dry and damp locations; 600V, maximum operating temperature 90o C (194o F). Insulation, flame retardant, heat resistant, thermoplastic; outer covering, nylon jacket; conductor, annealed copper.

E. Cables: Provide UL type factory-fabricated cables of sizes, ampacity ratings, and materials and jacketing/sheathing as indicated for services indicated. Where not indicated, provide proper selection as determined by Contractor to comply with installation requirements, NEC and NEMA standards.

F. Conductors No. 10 and smaller shall be solid and conductors larger than No. 10 shall be stranded. Fire alarm wiring shall be stranded.

G. Conductors shall be of solid, high electrical conductivity copper with a cross-section area corresponding to standard AWG sizes.

H. The insulation shall be of highly compressed magnesium oxide that will provide proper spacing for conductors. Thickness of insulation shall be at least 55 mils for all cable from 14 AWG through 250 MCM.

I. Conductors:

1. Gauge: 12 AWG minimum.

2. Type: Solid or stranded.

3. Insulation: Rated for 90o C (194o F).

J. Grounding: Full size ground wire.

K. Low signal level instrumentation cables shall have the following features:

1. Conductor:

a. Gauge:16 AWG

b. Type: Stranded

2. Insulation: Chemically cross-linked polyethylene or flame retardant ethylene propylene, 90o C, 600 volts.

L. Connectors:

1. General: Provide third party agency complied metal connectors of sizes, ampacity ratings, materials, types and classes for applications and for services indicated.

2. Where not indicated, provide proper selection as determined by the Installer to comply with the project's installation requirements, and with NEC and NEMA standards.

3. Select from the following, those types, classes, kinds and styles of connectors to fulfill project requirements:

   a. Type: Pressure, threaded.

   b. Class: Insulated.

   c. Kind: Copper (for Cu to Cu connection).

   d. Style: Tap, pigtail, wirenut, split bolt, T connections.

2.02 CONNECTORS AND SPLICES

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

   1. Hubbell Power Systems, Inc.

   2. O-Z/Gedney; EGS Electrical Group LLC.

   3. 3M; Electrical Products Division.

   4. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

C. Joints in solid conductors shall be spliced using Ideal "Wirenuts", 3M Company "Scotchlock" or T&B "Piggy" connectors in junction boxes, outlet boxes and lighting fixtures.

D. "Sta-kon" or other permanent type crimp connectors shall not be used for branch circuit connections.

E. Joints in stranded conductors shall be spliced by approved mechanical connectors and gum rubber tape or friction tape. Solderless mechanical connectors for splices and taps, provided with U/L approved insulating covers, may be used instead of mechanical connectors plus tape.

F. Conductors, in all cases, shall be continuous from outlet to outlet and no splicing shall be made except within outlet or junction boxes, troughs and gutters.

2.03 SLEEVES FOR CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 7 Section "Through-Penetration Firestop Systems."

2.04 SLEEVE SEALS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Advance Products & Systems, Inc.
2. Calpico, Inc.
3. Metraflex Co.
4. Pipeline Seal and Insulator, Inc.

C. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.

1. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.

2. Pressure Plates: Plastic. Include two for each sealing element.

3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

3.00 EXECUTION

3.01 GENERAL

A. No wiring will be pulled in underslab conduit until the concrete slab has been poured over the entire run of conduit.

3.02 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded class B for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.03 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS

AND WIRING METHODS

A. Service Entrance: Type THHN-THWN or XHHW, single conductors in raceway.

B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-THWN, single conductors in raceway.

C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

D. Feeders Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway. E. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-THWN, single conductors in raceway.

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.

G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

H. Branch Circuits Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway.

I. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless- steel, wire-mesh, strain relief device at terminations to suit application.

J. Class 1 Control Circuits: Type THHN-THWN, in raceway.

K. Class 2 Control Circuits: Type THHN-THWN, in raceway.

3.04 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. 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.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to Division 16 Section "Electrical Supports and Seismic Restraints." F. Identify and color-code conductors and cables according to Division 16 Section "Electrical Identification."

G. Where the conductor length from the panel to the first outlet on a 227 volt circuit exceeds 125 feet, the branch circuit conductors from the panel to the first outlet shall not be smaller than #10 AWG.

H. Where the conductor length from the panel to the first outlet on a 120 volt circuit exceeds 50 feet, the branch circuit conductors from the panel to the first outlet shall not be smaller than #10 AWG.

I. General: Install wires and wiring connectors as indicated, in compliance with applicable requirements of NEC, NEMA, UL, and NECA's "Standard of Installation," and in accordance with recognized industry practices.

J. Coordinate wire/cable installation work including electrical raceway and equipment installation work, as necessary to properly interface installation of wires/cables with other work.

K. Use no wire smaller than 12 AWG for power and lighting circuits, and no smaller than 14 AWG for control wiring (fire alarm).

L. Use minimum 10 AWG conductor for 20 ampere, 120 volt branch circuit home runs longer than 50 feet.

M. Use minimum 10 AWG conductor for 20 ampere, 277 volt branch circuit home runs longer than 125 feet.

N. Place an equal number of conductors for each phase of a circuit in same raceway, unless indicated otherwise on the Drawings.

O. Neatly train and lace wiring inside boxes, equipment and panelboards.

P. Make conductor lengths for parallel circuits equal.

Q. Conductors shall be color coded; (1) ground leads, green; (2) isolated ground, green with yellow stripe; (3) grounded neutral leads, white (120 volts) or natural gray (277 volts); (4) ungrounded phase wires, black, red, and blue (208Y/120V); (5) ungrounded phase wires, brown, orange, and yellow (480Y/277V); (6) switch leg travelers, purple. Conductors No. 4 and larger shall be taped per the latest edition of the NEC, except isolated ground shall have suitable yellow tape applied to conductor.

R. Install exposed cables parallel and perpendicular to surfaces, or exposed structural members, and follow surface contours, where possible.

S. Completely and thoroughly swab raceway system before installing conductors.

T. Branch circuit wiring shall not loop through receptacle terminals, but shall be connected by means of conductor taps joined to branch circuit conductors. At end of run, branch circuit conductors may terminate on receptacle terminals.

U. Position all splices in pull boxes and junction boxes of adequate volume so they are accessible from the removable cover side of the box.

V. Conductors for signal systems shall be continuous and shall be terminated on terminal strips or terminate in a manner approved by the system's manufacturer.

W. All neutrals and ground wires in panels shall be labeled with numbered tape to indicate the circuits being served.

X. Pull conductors simultaneously where more than one is being installed in same raceway.

Y. Use pulling compound or lubricant, where necessary; compound used must not deteriorate conductor or insulation.

Z. Use pulling means including fish tape, cable, rope and basket weave wire/cable grips which will not damage cables or raceway.

3.05 CONNECTIONS AND SPLICES

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 and UL 486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack. D. Keep conductor splices to minimum.

E. Install splices and taps which possess equivalent or better mechanical strength and insulation ratings than conductors being spliced.

F. Use splice and tap connectors which are compatible with conductor material.

G. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standard 486A and B.

H. Conductors manufactured more than twelve months prior to date of delivery to site shall not be used.

I. Splice only in accessible junction boxes.

J. Splices, taps and attachments of fittings and lugs shall be electrically and mechanically secure. Connectors and lugs shall be correct size for conductors jointed.

K. Solid conductors, namely those sized No. 10, No. 12 AWG copper, and smaller, shall be spliced by using Ideal "Wire-Nuts," 3M Co.'s "Scotchlok" or T&B "Piggy" conductors in junction boxes and light fixtures, except recessed fixtures as noted below.

L. "Sta-Kon" or other permanent type crimp connectors shall not be used.

M. Contractor shall use Ideal "Wing-Nuts" for splicing recessed lighting fixture leads to branch circuit conductors.

N. Stranded conductors, namely No. 8 AWG and larger, shall be spliced by UL listed mechanical connectors plus gum tape, plus friction or plastic tape. Solderless mechanical connectors, for splices and taps, provided with UL listed insulating covers, may be used instead of mechanical connectors plus tape.

O. Conductors, in all cases, shall be continuous from outlet to outlet, and no splicing shall be made except within outlet or junction boxes, troughs, and gutters.

P. Lugs for conductors No. 6 through No. 1/0 AWG shall be copper, split bolt type with spacer. Lugs for connectors No. 2/0 AWG and larger shall be copper 2-bolt type with spacer. Lugs shall be as manufactured by AMP, Inc., or reviewed equal.

Q. Taping of joints shall be made using special oil resistant vinyl plastic tape; UL listed, rated 105o C, Scotch Electrical Tape No. 33+ or reviewed equal.

R. Splices in grounding conductors No. 8 AWG and larger shall be by means of exothermic welding and termination shall be by means of approved grounding connectors. Soldering shall not be used.

S. Thoroughly clean wires before installing lugs and connectors.

T. Make splices, taps and terminations to carry full ampacity of conductors without perceptible temperature rise.

U. Terminate spare conductors with electrical tape.

3.06 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 7 Section "Through-Penetration Firestop Systems."

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Rectangular Sleeve Minimum Metal Thickness:

1. For sleeve rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch .

2. For sleeve rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.

E. 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.

F. Cut sleeves to length for mounting flush with both wall surfaces.

G. Extend sleeves installed in floors 2 inches above finished floor level.

H. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and cable unless sleeve seal is to be installed.

I. Seal space outside of sleeves with grout for penetrations of concrete and masonry.

J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 7 Section "Joint Sealants."

K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 7 Section "Through-Penetration Firestop Systems."

L. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.

M. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

N. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.07 SLEEVE-SEAL INSTALLATION

A. Install to seal underground exterior-wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.08 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 7 Section "Through-Penetration Firestop Systems."

3.09 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. All current carrying phase conductors and neutrals shall be tested as installed, and before connections are made, for insulation resistance and accidental grounds. This shall be done with a 500 volt megger. The procedures listed below shall be followed:

a. Minimum readings shall be one million (1,000,000) or more ohms for #6 AWG wire and smaller, 250,000 ohms or more for #4 AWG wire or larger, between conductors and between conductor and the grounding conductor.

b. After all fixtures, devices and equipment are installed and all connections completed to each panel, the contractor shall disconnect the neutral feeder conductor from the neutral bar and take a megger reading between the neutral bar and the grounded enclosure. If this reading is less than 250,000 ohms, the contractor shall disconnect the branch circuit neutral wires from this neutral bar. He shall then test each one separately to the panel and until the low readings are found. The contractor shall correct troubles, reconnect and retest until at least 250,000 ohms from the neutral bar to the grounded panel can be achieved with only the neutral feeder disconnected.

c. At final inspection, the contractor shall furnish a megger and show the engineers that the panels comply with the above requirements. He shall also furnish a hook-on type ammeter and voltmeter to take current and voltage readings as directed by the representatives. Provide for factory authorized technicians to perform testing in according to the manufacturer's recommendations.

2. Provide for factory authorized representative to perform testing ccording to the manufacturer's recommendations.

3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible t portable scanner.

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 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.

C. Test Reports: Prepare a written report t

1. Test procedures used.

2. Test results that comply with requi

3. Test results that do not comply wit compliance with requirements.

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

E. Prior to energization of circuitry, check installed wires and cables with me determine insulation resistance levels to insure requirements are fulfilled.

F. Prior to energization, test wires and cables for electrical continuity and for proper phasing connections.

G. Subsequent to wire and cable hook-ups, energize circuitry and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning to demonstrate compliance.

H. Wire and Cable Installation Schedule:

I. Exposed Interior Locations: Building wire in raceway.

J. Above Accessible Ceilings: Building wire in raceway

K. Exterior Locations: Building wire in raceway.

L. Underground Locations: Building wire in raceway

END OF SECTION 16120

SECTION 16130
SURFACE RACEWAYS

1.00 GENERAL

1.01 DESCRIPTION OF WORK

A. Surface metal raceways.

B. Auxiliary gutters.

C. Wireways.

D. Wall troughs.

1.02 RELATED SECTIONS

A. Section 16050 - Basic Electrical Materials and Methods.

B. Section 16140- Wiring Devices, for wiring devices and boxes.

1.03 SUBMITTALS:

A. Shop Drawings: Show surface raceways, wireways and wall troughs.

B. Product Data: Describe surface metal raceways, auxiliary gutters, wireways, wall troughs, and accessories.

C. Informational Submittals: Manufacturer's Installation Instructions.

2.00 PRODUCTS

2.01 SURFACE METAL RACEWAYS

A. Manufacturers: Substitutions are permitted subject upon written request prior to bid submission.

1. Walker.
2. Wiremold.

B. Standards: NEC Article No. 352; UL.

C. Material: Steel, with primer and baked finish coat.

D. Fittings: Couplings, elbows, and connectors designed for use with raceway system.

E. Minimum Size: As listed by manufacturer for number of conductors used.

F. Boxes and Extension Rings: Designed for use with raceway systems.

G. Finish: Gray enamel.

2.02 AUXILIARY GUTTERS

A. Manufacturers: Substitutions are permitted subject to Section 01 63 00.
   1. Hoffman.
   2. Keystone.
   3. Penn Panel and Box Company.

B. Type: General purpose and Raintight as required wireway, with knockouts or without knockouts.

C. Standards: NEC Article No. 374.

D. Material: Steel, hot dip galvanized, with screw-on or hinged cover.

E. Finish: Rust inhibiting primer coat with gray enamel finish.

2.03 WIREWAYS

A. Manufacturers: Substitutions are permitted subject to Section 01 63 00.
   1. General Electric.
   2. Hoffman.
   3. Keystone.
   4. Square "D" Square Duct.

B. Standards: NEC Article No. 362; UL.

C. Material: Steel, gray enamel finish, with hinged cover; conduit knockouts.

D. Size: Minimum 4 inch square; other sizes as shown.

E. Accessories: Hinged connectors; elbows; fittings for changes in direction; cutoff fittings; hangers; closing plates; cabinet adapters; wire retainers; escutcheon plates; other modifications and accessories as required.

2.04 WALL TROUGHS

A. Design Standard Manufacturer: SQUARE "D". Substitutions subject to Section 01600 are:

   1. General Electric.
   2. Walker.
   3. Other Substitutions are permitted subject to Owner's review and approval.

B. Description: Lay-in surface wall mounted wireway with 14 gauge steel backboxes, 12 gauge steel screw cover plate, and 16 gauge steel internal partitions.

C. Finishes:
   1. Backboxes: Galvanized steel with rust inhibitor prime coat.
   2. Partitions: Galvanized steel.
   3. Cover Plate: Prime coat of rust inhibitor, and finish coat of gray baked enamel.

D. Accessories: Elbows; end caps; trough connectors; cabinet connectors; couplings; split cover plates; rubber grommets; conduit connections; other modifications and accessories as required.

3.00 EXECUTION

3.01 SURFACE METAL RACEWAYS

A. Mount raceway level. Fasten securely on walls, benches, and other locations shown. Cut raceway in field to required length. Install fittings and other accessories.

B. In unfinished spaces, feed raceway with flexible or liquidtight conduit from surface mounted outlet box on wall.

C. In finished spaces, feed raceway from recessed outlet box in wall.

D. Where raceway is mounted on furniture, use cover plate on outlet box with conduit connector in face. Extend flexible or liquidtight conduit to raceway.

3.02 AUXILIARY GUTTERS

A. Mount auxiliary gutter level to steel channels fastened to wall or in self-supporting structure.

B. Gasket each joint in oil-tight gutter.

C. Mount raintight gutter in horizontal position only.

3.03 WIREWAYS

A. Install wireways in accordance with NEC Article 362. Provide hinged connectors to join adjacent lengths. Connect sections soundly to ensure effective grounding of wireway system.

B. Mount wireway with hinged section in accessible location.

C. Use standard manufactured lengths to fit in available space. Where non-standard length is required, cut as required and provide cut-off fitting.

D. Provide offsets and appropriate fittings as required to clear obstructions.

E. Install hangers 1524 mm (60 inches) OC maximum, with at least one hanger for each length of wireway.

F. Install closing plates at ends of wireway. Install wire retainers in wireway after conductors are in place. Provide adapter where wireway is connected to box and cabinet.

G. Use 300 mm (12 inch) section of wireway to pass through walls, to allow accessibility on each side. Install special escutcheon plate on each side of wall to finish opening neatly.

3.04 WALL TROUGHS

A. Install wall trough square with building lines. Fasten securely to wall surface. Use trough with non-removable cover where partitions are penetrated.

B. Field measure rooms in which trough is to be installed. Provide special lengths as required to fit available space. Make conduit openings in field for proper coordination.

END OF SECTION 16130

SECTION 16139
CABLE TRAYS

1.00 GENERAL

1.01 DESCRIPTION OF WORK

A. The work includes all labor, materials, equipment and services necessary for the installation of a complete cable tray system.

B. The requirements of Divisions 15 and 16 Mechanical and Electrical General Provisions shall apply to all work specified under this Section.

1.02 SUBMITTALS:

A. Product Data: Submit manufacturer's data on components.

B. Shop Drawings: Submit detailed shop drawing with dimensions of all system components and accessories. Describe wire basket cable trays and accessories. Show gauges and finishes.

C. Informational Submittals:

1. Manufacturer's Installation Instructions.

2.00 PRODUCTS

2.01 CABLE TRAY

A. Manufacturers: Substitutions are permitted subject to Section 01630.

1. B-Line.
2. GS Metals Flextray
3. Cablofil EZTray

B. Standards: NEC Article No. 392; NEMA 5CT, NEMA VE-1; and NEMA VE-2; UL.

C. Material: Carbon steel wire, ASTM A 510, Grade 1008. Wire welded, bent, and surface treated after manufacture.

D. Dimensions: 4 inch usable depth; 12 inch width as shown, unless otherwise noted.

E. Type:

1. Continuous hook or basket type metallic cable tray; 4 inch deep x 12 inch wide, unless otherwise noted.
2. Load: Provide support brackets and hangars to support fully loaded tray system. The distance between supports shall not exceed 2440 mm (8 feet).
3. Cable tray shall be UL listed as an equipment grounding conductor.

F. Bonding

1. Wire basket cable tray shall be electrically continuous. Provide #6 AWG green ground copper wire bonding with listed clamps to ensure electrical continuity.

3.00 EXECUTION

3.01 INSTALLATION

A. Support cable tray on a maximum of 2440 mm (8 foot) centers and at bends and T fittings, with steel rods, 13 mm (1/2 inch) diameter minimum.

B. Connect sections of cable tray together with edges free from burrs and sharp projections.

C. Arrange cable trays and allow sufficient space to permit access for installing and maintaining cables.

D. Comply with NEC 392 for allowable cable fill area.

E. Where the tray is discontinuous, the Contractor shall make the tray electrically continuous using a #6 AWG green ground conductor. The ground conductor shall be attached to the tray using the manufacturer's recommended connector.

F. Bond all raceways associated with the tray to the tray using the manufacturer's U.L. listed fittings.

3.02 TESTING

A. Test wire basket support systems to ensure electrical continuity of bonding and grounding connections, and to demonstrate compliance with specified maximum grounding resistance.

END OF SECTION 16139

SECTION 16140
WIRING DEVICES

1.00 GENERAL

1.01 SECTION INCLUDES

A. Outlet boxes.

B. Pull and junction boxes.

C. Floor boxes.

D. Surface-type service fittings.

E. Through-floor service fittings; poke-through.

F. Convenience receptacles.

G. Ground fault interrupter receptacles.

H. Clock hanger receptacles.

I. Local switches.

J. Device plates.

K. Local timer switches.

L. Occupancy sensors.

M. Receptacle strip.

N. Multi-outlet assembly.

O. Laboratory casework mounted outlets.

1.02 RELATED SECTIONS

A. Section 078141- Firestopping and Firesafing.

B. Section 16050 - Basic Electrical Materials and Methods.

1.03 SUBMITTALS: Follow Section 01 33 00.

A. Product Data: Describe configurations, finishes, colors, and dimensions for floor boxes, receptacles, switches, device plates, dimming switches, dimming systems, occupancy sensors, receptacle strips, multi-outlet assemblies.

B. Informational Submittals:

1. Manufacturer's installation instructions.
2. Special Warranty: Warrant occupancy sensor switches for 5 years from date of Substantial Completion.

2.00 PRODUCTS

2.01 OUTLET BOXES

A. Manufacturers: Substitutions are [not permitted] [permitted subject to Section 01 63 00].

1. Appleton.
2. Raco.
3. Steel City.

B. Standards: NEC Article No. 314; UL.

C. Material: Pressed steel, zinc coated.

D. Minimum Size: 4 inch square or octagon; depth as required.

E. Extension Rings: To suit various conditions.

F. Hardware: Grounding screw and connectors as required by wiring method.

G. Other Types: As required to suit conditions.

2.02 PULL AND JUNCTION BOXES

A. Manufacturers: Substitutions are [not permitted] [permitted subject to Section 01 63 00].

1. Hoffman.
2. Keystone.
3. O.Z./Gedney.

B. Standards: NEC Article No. 314; ASTM A123; UL.

C. Material: Galvanized steel, code gauge.

D. Cover: Same material as box, screw on type, maximum size 300 sq. in. in one piece.

2.03 WATERTIGHT SPLICE AND PULL BOXES

A. Manufacturer: Quazite Corporation. Substitutions are [not permitted] [permitted subject to Section 01 63 00].

B. Standards: NEC Article No. 314; ASTM A123; UL.

C. Underground Enclosures: Polymer concrete, PC Style gasketted boxes, [green] [black] color; rated for at least 8000 pounds over 10 square inch area, at temperatures to minus 50 degrees F. Stackable for extra depth. Material compressive strength at least 11,000 psi. Solid base.

D. Cover Logo: "Electric" for receptacle circuits; ["Street Lighting"] ["Lighting"] for lighting circuits; ["Telephone"] ["Communications"] ["Fiber Optics"] ["C.A.T.V"] for communication circuits.

E. Stainless steel inserts and bolts.

2.04 FLOOR BOXES FOR TILED FLOORS

A. Design Standard Manufacturer: HUBBELL. Substitutions subject to Section 01 63 00 are:

1. Wiremold
2. Thomas and Betts
3. Other substitutions are [not permitted] [permitted subject to Section 01 63 00].

B. Manufacturer's Designation:

1.	Single gang box:	B2436
2.	Single gang cover, power:	S3625
3.	Single gang cover, telephone:	S2425
4.	Double gang box:	B4233
5.	Cover double gang box:	(1) S3625, (1) S2425
6.	Floor fitting, telephone:	SC3099A
7.	Floor fitting, power:	SC3098A

C. Standards: NEC Article No. 314; UL.

D. Body: Fully adjustable before and after concrete placement; cast iron; threaded hubs for conduit of size required; four adjustable legs; single gang-rectangular, 3 inches high; double gang-rectangular.

E. Cover: Flush with floor; gaskets for waterproof installation, meets UL514A & UL514C standards; satin finish forged aluminum.

F. Floor Fitting: Low silhouette, die cast aluminum, and adjustable base plate.

1. High Tension Fitting: One insert with one 20A duplex convenience receptacle Hubbell # HBL5362 to match wiring devices; one blank insert.
2. Low Tension Fitting: One insert with one bushed opening; one blank insert.

G. Accessories: Temporary protective caps to cover body during installation; flush convenience receptacles where floor fittings are not used; satin brass exposed surfaces where indicated; others as required for Project.

H. Other Types: As shown.

2.05 FLOOR BOXES FOR CARPETED FLOORS

A. Design Standard Manufacturer: HUBBELL. Substitution subject to Section 01 63 00 is:

1. Wiremold.
2. Thomas and Betts.
3. Other substitutions are [not permitted] [permitted subject to Section 01 63 00].

B. Manufacturer's Designation:

1.	Stamped Steel Box:	3SFBSS663
2.	ABS Cover & Flange Assembly:	3SFBCBRA
3.	Receptacle Plate:	3SFBRP
4.	Blank Plate:	SFBB
5.	Voice / Data Plate	3SFBS
6.	Single Receptacle Plate	3SFBS
7.	Style Line Plate	3SFBDS

C. Standards: NEC Article No. 314; UL.

D. Body: Stamped steel with knock-outs for 3/4 inch, 1 inch, and 1 1/4 inch conduits; shall accommodate convenience outlet and communication devices below floor surface;

E. Cover: Thermoplastic (ABS) cover & flange assembly with heavy gauge steel plate.

F. Assembly shall include floor box with 20 Amp duplex convenience receptacle Hubbell #HBL5362, [telephone and communication outlets].

G. Other Types: As indicated.

2.06 SURFACE-TYPE SERVICE FITTINGS

A. Design Standard Manufacturer: HUBBELL. Substitutions subject to Section 01 63 00 are:

1. Wiremold.
2. Thomas and Betts.
3. Other substitutions are [not permitted] [permitted subject to Section 01 63 00].

B. Surface-type Service Fitting for Convenience Receptacle: [Satin aluminum] [SC3098A] housing with [stainless steel] [SS309D] device plates for [one] [two, back-to-back] duplex convenience receptacles.

C. Surface-type Service Fitting for Communications: [Satin aluminum] [SC3099A] housing with [stainless steel] [SS309T) plates with [one] [two, back-to-back] 1 inch ID bushed openings.

2.07 THROUGH-FLOOR SERVICE FITTINGS POKE-THROUGH

A. Design Standard Manufacturer: HUBBELL. Substitutions subject to Section 01 63 00 are:

1. Wiremold
2. Thomas and Betts
3. Other substitutions are [not permitted] [permitted subject to Section 01 63 00].

B. Manufacturer's Designation:

1.	2" Through Floor Fitting:	PT27A
2.	3" Through Floor Fitting:	PT7XC
3.	2 - Gang Back to Back Pedestal:	FR280GYA
4.	4 – Gang Back to Back Pedestal:	FR480GYA
5.	6 – Gang Back to Back pedestal:	FR680GYA
6.	Low Voltage Barrier:	FRBR1
7.	Duplex Face Plate:	SS2309DGYA
8.	Voice / Data Face Plate:	SS2309TGYA
9.	Style Line / GFCI Face Plate:	SS2309SLGYA
10.	Extension Kit:	EXT13
11.	Abandoning Closure Plug:	FRP250

C. Description: Unit consisting of:

Edit fire rating and floor thickness. Coordinate with project architect and/or structural engineer.

1. Through-floor assembly for wiring of floor outlets for power and/or communication; UL listed; [two][four] hour fire rating for use in floors from 2 1/2 inches to 8 inches thick.
2. Fire stops and smoke barriers in through-floor component, floor service box at top with 20 amp receptacle pre-wired and ending in box at bottom with adequate lead wires.
3. A fire-rated center coupling with separate raceway for power and communication, factory equipped with inorganic chemical panels that will expand on exposure to high heat to form a flame, smoke, and air seal throughout assembly.
4. A barrier extension channel and a barrier junction box at bottom, with screws for leveling box in place.

D. Finish: Satin die cast aluminum.

2.08 CONVENIENCE RECEPTACLES (STANDARD)

A. Design Standard Manufacturer: HUBBELL. Substitutions subject to Section 01 63 00 are:

1. Cooper Wiring Devices.
2. Leviton.
3. Pass and Seymour.
4. Other substitutions are [not permitted] [permitted subject to Section 01 63 00].

B. Manufacturer's Designation: HBL5362.

C. Standards: NEC Article No. 406; Fed. Spec. W-C-596D as verified by UL and NEMA tests WD-1, 3.02 through 3.10 and UL tests UL498.

D. Type: Duplex, 2 pole, 3 wire, with U slot ground.

E. Construction: Heavy duty, industrial specification grade.

F. Contacts: 20 ampere, phosphor bronze, double wiping.

G. Wiring Terminal Type: Back and side. [Option: Plug-in connector with pig-tails]

H. Grounding Terminals: Green screw.

I. Other Types: As shown or required to match plugs for equipment furnished by Owner or other trades.

2.09 CONVENIENCE RECEPTACLES, ISOLATED GROUND

A. Design Standard Manufacturer: HUBBELL. Substitutions subject to Section 01 63 00 are:

1. Cooper Wiring Device.
2. Leviton.
3. Pass and Seymour.
4. Other substitutions are [not permitted] [permitted subject to Section 01 63 00].

B. Manufacturer's Designation: IG-5362.

C. Standards: NEC Article No. 406; NEMA Standard WD-1, and WD-5; UL 498; ANSI C73. Grounding terminal isolated from mounting yoke. Heavy duty industrial specification grade.

D. Type: Duplex, 2 pole, 3 wire, with U slot ground.

E. Construction: Nylon body and face.

F. Contacts: 20 ampere, 125V, phosphor bronze, double wiping.

G. Grounding Terminals: Green screw.

H. Other Types: As shown or required to match plugs for equipment furnished by Owner or other Trades.

2.10 GROUND FAULT CIRCUIT INTERRUPTER RECEPTACLES

A. Design Standard Manufacturer: HUBBELL. Substitutions subject to Section 01 63 00 are:

1. Cooper Wiring Devices.
2. Leviton.

3. Pass and Seymour.
4. Other substitutions are [not permitted] [permitted subject to Section 01 63 00].

B. Manufacturer's Designation: GFR5352L

C. Standard: NEC Article 406, UL 943, Class A; ANSI CI-1975; NEC; NEMA WD-1; UL 498; and ANSI C73.

D. Type: Heavy duty industrial specification grade, duplex; 125VAC GFI with indicating LED light; 5ma trip threshold.

E. Construction: Electronic circuit board with surge suppressor; indicating light; moisture resistant circuit interrupter; wire connectors; shall fit in standard box; with test switch.

F. Contacts: 20 ampere double wipe.

2.11 CLOCK HANGER RECEPTACLES

A. Design Standard Manufacturer: HUBBELL. Substitutions subject to Section 01 63 00 are:

1. Cooper Wiring Devices.
2. Leviton.
3. Pass and Seymour.
4. Other substitutions are [not permitted] [permitted subject to Section 01 63 00].

B. Manufacturer's Designation: HBL5235.

C. Standards: NEC Article No. 406; NEMA; UL.

D. Type: Single, 2 pole, 3 wire, with U slot ground.

E. Construction: Heavy duty, industrial specification grade.

F. Contacts: 15 amp., phosphor bronze.

G. Cover Plate: Integral hook for clock, recess for male cap, finish to match device plates.

2.12 LOCAL SWITCHES

A. Design Standard Manufacturer: HUBBELL. Substitutions subject to Section 01 63 00 are:

1. Cooper Wiring Devices.
2. Leviton.
3. Lutron.
4. Pass and Seymour.
5. Other substitutions are [not permitted] [permitted subject to Section 01 63 00].

B. Manufacturer's Designation: HBL1221, HBL1223, HBL1224.

C. Standards: NEC Article No. 404; NEMA; UL.

D. Construction: Heavy duty, industrial specification grade, 20A at 120/277V, 2 hp at 240V, 1 hp at 120V.

E. Type: Flush, quiet, AC, totally enclosed brush tumbler, toggle handle, single pole, 3-way and 4-way as shown.

F. Modifications: Pilot light, key operation, interchangeable type as shown.

G. Wiring Type: Back and side, for #10 AWG if required.

H. Other Types: As shown or specified.

2.13 DEVICE PLATES

A. Manufacturer: Same as wiring device manufacturer.

B. Standards: NEC Articles No. 404 and No. 406; UL.

C. For Exposed Boxes: Cadmium plated steel.

D. For Recessed Boxes: [High abuse reinforced nylon.] Color: Ivory [Brown]. [Stainless steel, brushed finish.]

E. Type: To suit device.

F. Ganging: As required by number of devices.

G. Weatherproof: Gasketted, cast aluminum, spring-loaded lift cover plates.

H. Engraving: ["EMERGENCY"] ["CRITICAL"] for devices connected to emergency system; 3/16 inch high characters; Red. Engrave long side of plate where wiring device is mounted horizontally; other engraving as indicated.

I. Other Types: As shown or specified.

2.14 LOCAL TIMER SWITCHES

A. Design Standard Manufacturer: Watt Stopper “TS-400”. Substitution subject to Section 01 63 00 is:

1. Tork.
2. Other substitutions are not permitted.

B. Standards: UL, ANSI/IEEE, California Title 24 listed.

C. Performance: Wall mounted, digital timing switch with adjustable time pre-set (5 minutes to 12 hours) and OFF switch, and one minute advance flash warning before lights switch off; optional beep warning every five seconds once remaining time reaches one minute; lights can be switched off at any time during the time cycle by pressing the on/off switch.

D. Rating: 120 or 277 volt, 1200 watt fluorescent load, compatible with electronic ballasts and compact fluorescent lamping: zero crossing circuitry. Provide low voltage device and associated power pack where used to control loads 1200 watts and higher.

E. Provide five year product warranty.

2.15 OCCUPANCY SENSOR SWITCHES – WALL MOUNTED

A. Design Standard Manufacturer: Watt Stopper "WS-200". Substitution, subject to Section 01 63 00:

1. Sensor Switch.
2. Other substitutions are not permitted.

B. Standards: UL, California Title 24 listed.

C. Performance: Wall mounted motion sensor using infrared to detect moving personnel (minimum 300 square foot coverage for desktop activity). When motion is detected lights switch ON; if no motion is detected after a pre-selected (adjustable) duration, lights automatically switch OFF. Selectable automatic or manual control mode, integrated light level sensor, adjustable intensity (2 to 200 footcandles), light level and time delay switches, and compatible with electronic ballasts.

D. Rating: 0-800 watts at 120V; 0-1200 watts at 277V.

E. Provide five year product warranty.

2.16 DUAL-LEVEL OCCUPANCY SENSOR SWITCHES – WALL MOUNTED

A. Design Standard Manufacturer: Watt Stopper "WA-300". Substitution subject to 01 63 00:

1. Sensor Switch.
2. Other substitutions are not permitted.

B. Standards: UL, California Title 24 listed.

C. Description: Wall mounted infrared motion sensor capable of controlling two independent lighting loads or circuits with isolated second relay; selectable time delay before shutting off lights (5, 10, 15, 20, or 30 minutes); dual on/off buttons for independent control of loads; integrated adjustable light level sensor for controlling secondary relay (8 to 180 footcandles); compatible with electronic ballasts.

D. Rating: 0-800 watts at 120V; 0-1200 watts at 277V.

E. Finish: White.

F. Provide five year product warranty.

2.19 OCCUPANCY SENSOR SWITCHES – DIRECTIONAL CEILING/WALL MOUNTED

A. Design Standard Manufacturer: WATT STOPPER "DT-200". Substitutions subject to 01 63 00:

1. Sensor Switch.
2. Other substitutions are not permitted.

B. Standards: UL, California Title 24 listed.

C. Performance: Ceiling mounted dual technology (infrared and ultrasonic) directional motion sensor; detection range up to 50 feet from sensor. When motion is detected lights switch ON; if no motion is detected after a pre-selected (adjustable) duration, lights automatically switch OFF. Provide with integrated light level sensor, adjustable intensity (from 3 to 200 footcandles); time delay (15 seconds to 30 minutes) switches, and compatible with electronic ballasts.

D. Rating: 24VDC; 19mA.

E. Provide five year product warranty.

F. Accessories: Provide quantity required to adequately switch loads controlled via occupancy sensor.

1. Power Pack: Provides 24VDC operating power to sensors, and switches up to 20 amps of ballasted load. Provide 120 or 277V, as required.
2. Slave Pack: Switches up to 20 amps of ballasted load. Provide 120 or 277V, as required.

2.20 OCCUPANCY SENSOR SWITCHES - 360 DEGREE CEILING MOUNTED

A. Design Standard Manufacturer: Watt Stopper "DT-355". Substitution subject to Section 01 63 00:

1. Sensor Switch.
2. Other substitutions are not permitted.

B. Standards: UL, California Title 24 listed.

C. Performance: Ceiling mounted 360 degree dual-technology (infrared and ultrasonic) occupancy sensor with 1400 sq ft coverage. When occupancy is detected lights switch ON; if occupancy is not detected after a pre-selected (adjustable) duration, lights automatically switch OFF. Provide integrated light level sensor, adjustable intensity (10 to 300 footcandles); and adjustable time delay (5 to 30 minutes). Unit shall be compatible with electronic ballasts.

D. Rating: 120/277V.

E. Provide five year product warranty.

2.21 OCCUPANCY SENSOR SWITCHES - 180 DEGREE CEILING MOUNTED

A. Design Standard Manufacturer: Watt Stopper "W-2000H". Substitution subject to Section 01 63 00:

1. Sensor Switch.
2. Other substitutions are not permitted.

B. Standards: UL, California Title 24 listed.

C. Performance: Ceiling mounted 180 degree ultrasonic occupancy sensor with 90 linear ft coverage. When occupancy is detected lights switch ON; if occupancy is not detected after a pre-selected (adjustable) duration, lights automatically switch OFF. Provide integrated light level sensor, adjustable intensity (10 to 300 footcandles); and adjustable time delay (5 to 30 minutes). Unit shall be compatible with electronic ballasts.

D. Rating: 120/277V.

E. Provide five year product warranty.

2.22 LINE VOLTAGE PHOTOCELL – EXTERIOR

A. Design Standard Manufacturer: Paragon, CW201-71. Substitution subject to Section 01 63 00:

1. Tork.
2. Other substitutions are not permitted.

B. Standards: UL, ANSI, IEEE, California Title 24 listed.

C. Performance: Conduit mounted, UL wet label photocell with adjustable ambient illumination range; integral time delay to prevent false switching. Operable temperature range of -40 to 140 degrees F. Factory set at lowest level of light sensitivity, and 15 minute time delay.

D. Rating: 277V, 1900VA ballasted load, 2000 watt tungsten load. UL listed for wet locations.

E. Provide three year product warranty.

2.28 RECEPTACLE STRIP

A. Design Standard Manufacturer: WIREMOLD. Substitutions subject to Section 01 63 00 are:

1. Mono-Systems, Inc.
2. Thomas and Betts.
3. Other substitutions are [not permitted] [permitted subject to Section 01 63 00].

B. Manufacturer's Designation: No. 2200, Series GA.

C. Standards: NEC Article No. 380; UL.

D. Raceway: 0.040 inch steel base and 0.025 inch steel cover, length as required, cut for 2 receptacles with space for circuit conductors and 10 extra No. 12 wires.

E. Receptacles: Single, U-slot grounding type, [30 inch] OC, alternately connected.

F. Fittings: Blank end fittings, couplings, covers, corners, elbows and other fittings designed for use with system.

G. Other Types: As shown or specified.

2.29 MULTI-OUTLET ASSEMBLY – STEEL

A. Design Standard Manufacturer: WIREMOLD. Substitution subject to Section 01 63 00 is:

1. Mono-Systems, Inc.
2. Thomas and Betts.
3. Hubbell.
4. Other substitutions are [not permitted] [permitted subject to Section 01 63 00].

B. Manufacturer's Designation: No. G-3000.

C. Standards: NEC Article No. 380; UL.

D. Description: Two-piece raceway 1-15/32 inch x 2-3/4 inch with 0.040 inch steel base and 0.025 inch steel cover; sized to accommodate conventional wiring devices [and cover plates]; prime coated for corrosion protection [and finished with [ivory] [custom color] [gray] baked enamel[, suitable for field painting].

E. Fittings: Blank end fittings, couplings, covers, elbows and other fittings designed for use with system.

F. Other Types: As shown or specified.

G. Receptacles: As shown or specified.

2.30 MULTI-OUTLET ASSEMBLY – ALUMINUM

A. Design Standard Manufacturer: WIREMOLD. Substitution subject to Section 01 63 00 is:

1. Mono Systems.
2. Hubbell.
3. Thomas and Betts.
4. Other substitutions are [not permitted] [permitted subject to Section 01 63 00].

B. Manufacturer's Designation: ALA3800.

C. Standards: NEC Article No. 380; UL.

D. Description: Two-piece raceway 2-1/4 inch x 3 inch with 0.078 inch extruded aluminum base and cover; sized to accommodate conventional wiring devices. Punched cover for respective receptacle or device. Finish: aluminum. [Special anodized color - [ ].]

E. Fittings: Designed by manufacturer for use with system.

F. Other Types: As shown or specified.

G. Receptacles: As shown or specified.

2.31 LABORATORY CASEWORK MOUNTED OUTLETS

A. Proprietary Manufacturer: WATER SAVER PRODUCT COMPANY. No substitutions.

B. Manufacturer's Designation:

1. Single face box with one duplex receptacle: E-300.
2. Double face box with two duplex receptacles: E-400.
3. Single face box with two duplex receptacles: E-500.
4. Double face box with four duplex receptacles: E-600.
5. Single face box for telephone and/or computer: E-300.

C. Description: Single and double face aluminum pedestal boxes. Duplex receptacles; as specified, with brushed stainless steel device plates. Furnish boxes for telephone and/or computer with a blank plate with bushed openings.

Coordinate colors with P/A or Interior Designer.

2.32 COLORS

A. Convenience Receptacles (Standard): [Ivory] [Brown] [White]; Red when connected to emergency system.

B. Convenience Receptacles (Isolated Ground): Orange.

C. Convenience Receptacles (Hospital Grade): Green dot on ivory face; red face when connected to emergency system; other colors as shown.

D. Ground Fault Circuit Interrupter Receptacles: Ivory [Brown] [White].

E. Clock Hanger Receptacles: Brown.

F. Local Switches: [Ivory] [Brown] [White].

G. Occupancy Sensors [Ivory] [White]

H. Timer Switches [Ivory] [White]

I. Receptacle Strip: [Ivory] [Brown] [White].

J. Multi-outlet Assembly: [Ivory] [Brown] [White].

K. Laboratory Outlets: [Ivory] [Brown] [White].

L. Device Plates (Exposed Boxes): Cadmium plated steel.

M. Device Plates (Recessed Boxes): [Stainless steel, satin finish, 0.040 inch thick.] [High abuse reinforced nylon, 0.10 inch thick, with reinforcing ribs; color [Ivory] [Brown] [White].]

3.00 EXECUTION

3.01 COORDINATION OF BOX LOCATIONS

A. Provide electrical boxes for splices, taps, wire pulling, equipment connections and code compliance. Size outlet, pull and junction boxes in accordance with NEC, or larger as shown.

B. Locations of electrical boxes are approximate unless dimensioned. [Obtain approval of floor box and outlet locations prior to rough-in].

C. Locate and install boxes to allow access. Where installation is inaccessible, coordinate locations and sizes of required access doors with Section 08 31 13. See Section 26 05 05 for access door coordination.

D. Locate and install boxes to maintain headroom and to present neat appearance.

3.02 OUTLET BOXES

A. Provide an outlet box for each outlet shown in the wiring system. Use 4 inch square minimum size with conduit, of appropriate size and configuration. Provide interior partitions where required. Use octagonal box for each individual lighting fixture and each continuous row of lighting fixtures in ceilings. Provide fixture stud for boxes that support lighting fixtures. Use cast iron, corrosion-resistant box with threaded hubs for exterior outlets; wet, damp and hazardous areas; and other locations indicated. Provide other boxes as required.

B. Install boxes square with building lines and fasten securely in place. Grout or patch plaster if masonry or gypsum board does not fit snugly on all sides of boxes.

C. Provide extension rings and raised cover plates in [plaster,] masonry, and tiled walls. Plug unused openings.

D. Use sectional boxes with appropriate cable clamps for cable wiring. Provide green grounding screw for connection to ground wires.

Delete if 480/277 volt system is not used.

E. Where multiple switches are used, avoid combinations of conductors that would introduce more than 300 volts between conductors in box. Use individual switch boxes, or gang boxes with internal partitions. If internal partitions are used, route conduits into appropriate sections of boxes to keep conductors isolated.

F. Do not install boxes back-to-back in walls. Provide minimum 6 inch separation, except provide minimum 24 inch separation in acoustic rated walls, to prevent transmission of sound.

G. Outlet boxes installed on opposite sides of a fire rated wall shall be separated by a minimum horizontal distance of 24 inches, separated by a horizontal distance of at least the depth of the wall cavity where the wall cavity is filled with cellulose loose-fill or mineral fiber insulation, or separated by solid fire blocking. Where these conditions cannot be met, a UL listed wall opening protective material such as the Hilti #CP617 putty pad, or approved equal, may be used. The wall penetration shall be limited to a maximum of 16 square inches.

H. Support boxes from building construction independently of conduit[.] [except for cast boxes that are connected to two rigid metal conduits, both supported within 12 inches of box.]

I. Use multiple-gang boxes where more than one device is mounted together; do not use sectional boxes. Provide barriers to separate wiring of different voltage systems.

J. Install boxes without damaging insulation.

K. Coordinate mounting heights and locations of outlets mounted above counters, benches, and backsplashes.

L. Position outlet boxes to locate luminaires as shown on reflected ceiling plans.

M. In inaccessible ceiling areas, position outlet and junction boxes within 6 inches of recessed luminaire, to be accessible through luminaire ceiling opening.

N. Install recessed outlet boxes in finished areas; secure boxes to interior wall and partition studs, accurately positioning to allow for surface finish thickness. Use stamped steel stud bridges for flush outlets in hollow stud wall, and adjustable steel channel fasteners for flush ceiling outlet boxes.

O. Align wall-mounted outlet boxes for switches, thermostats, and similar devices.

P. Securely fasten outlet boxes in suspended ceilings, used to mount exit lighting fixtures, to steel channels (Unistrut). Fasten channels to building construction.

Q. Adjust position of outlets in finished masonry walls in line with and perpendicular to masonry course lines.

R. For outlets mounted above or below counters, benches, or furniture, coordinate location and mounting heights with casework, millwork and furniture. Adjust outlet mounting height to agree with required location for equipment served.

3.03 PULL AND JUNCTION BOXES

A. Install pull boxes and junction boxes where required to facilitate installation of wiring, whether or not shown. Size boxes according to code. Provide interior partitions, insulated supports, hot dip galvanized angle iron braces, screw-on one-piece or split covers, ground connectors and other accessories as required.

B. Mount boxes in accessible but unobtrusive locations, such as closets and mechanical spaces.

C. Support pull and junction boxes from building construction independent of conduit.

3.04 FLOOR BOXES

A. Install and adjust floor boxes level with finished floor. Make installation water tight. Provide blank plugs for unused openings. Install carpet flanges on boxes in carpeted areas. Cover boxes with temporary caps to exclude foreign material during construction, including concrete placement.

B. Mount floor fittings securely on boxes where indicated. Remove screw plugs from floor boxes and deliver to Owner so that boxes can be closed off in future. Deliver unused fittings to Owner.

C. Confirm exact placement of boxes and related work before installing.

3.05 THROUGH-FLOOR SERVICE FITTINGS; POKE-THROUGH

A. Confirm exact placement and related work before installing.

B. Drill opening for poke-through fitting installation.

C. Install through-floor service fitting assemblies for one, two or three services.

D. Attach required hardware, conduits, junction boxes, and wire in ceiling space below.

E. Furnish [10] UL listed abandoning plates of same UL certified fire rating as fittings. Package, identify and deliver plates to Owner for future use.

3.06 WIRING DEVICE INSTALLATION

A. Install wall switches 1216 mm [48 inches] above floor, OFF position down, unless indicated otherwise.

B. Install convenience receptacles 457 mm [18 inches] above floor and grounding pole on bottom.

C. Install boxes for magnetic door hold open devices 100 mm (4 inches) below top of door at doors with top mounted closers, and 300 mm (12 inches) above finished floor at doors with floor closers. Coordinate these dimensions, together with horizontal dimensions required from door frame to box, with hardware supplier.

D. Install specific-use receptacles at heights shown.

E. Install decorative plates on switch, receptacle, and blank outlets in finished areas, [using jumbo size plates for outlets installed in masonry walls].

F. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface-mounted outlets.

G. Install devices and wall plates flush, plumb and level.

H. Provide waterproof seal around weatherproof cover plates installed indoors.

Edit the following paragraph as required for the project. Refer to NEC 406-8.

I. Provide weatherproof enclosure for receptacles installed outdoors where exposed to weather or in other wet locations. Integrity of weatherproof enclosure shall not be affected when receptacle is in use with attachment plug cap inserted. Provide enclosure that is weatherproof only when self-closing receptacle cover is closed for receptacles installed outdoors, where receptacles are provided for use for portable tools or other portable equipment normally connected to outlet only when attended.

3.07 OCCUPANCY SENSORS AND PHOTOCELLS

A. Factory set light sensor to lowest setting. Set sensitivity and time delay as required to prevent false switching. Perform test settings with A/E and O/R prior to setting switches for project.

3.08 RECEPTACLE STRIP AND MULTI-OUTLET ASSEMBLY

A. Mount unit level and securely fasten to walls. Mount unit on other surfaces where indicated. Cut in field to required length, and install fittings.

B. In unfinished areas, feed strip or assembly with flexible or liquidtight conduit from surface mounted outlet box on wall.

C. In finished areas, feed strip or assembly from recessed outlet box in wall. Where strip or assembly is mounted on wall, use manufactured wall box connector that will cover outlet box. Where strip or assembly is mounted on furniture, use cover plate on outlet box with conduit

connector in face, and extend flexible or liquidtight conduit to strip or assembly as required by conditions.

D. Coordinate raceway length and mounting height with casework, millwork, and furniture shop drawings.

END OF SECTION 16140

SECTION 16145
LIGHTING CONTROL DEVICES

1.00 GENERAL

1.01 SCOPE OF WORK

A. This Section includes the following lighting control devices:
   1. Time switches.
   2. Outdoor and indoor photoelectric switches.
   3. Indoor occupancy sensors.
   4. Outdoor motion sensors.
   5. Lighting contactors.
   6. Emergency shunt relays.

1.02 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Shop Drawings: Show installation details for occupancy and light-level sensors.
   1. Interconnection diagrams showing field-installed wiring.
C. Field quality-control test reports.
D. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1.03 DEFINITIONS

A. LED: Light-emitting diode.
B. PIR: Passive infrared.

1.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.05 COORDINATION

A. 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 system, and partition assemblies.

2.00 PRODUCTS

2.01 TIME SWITCHES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. LCD's.
   2. Intermatic, Inc.
   3. Leviton Mfg. Company Inc.

4. Lightolier Controls; a Genlyte Company.
5. Lithonia Lighting, Sensor Switch
6. Square D; Schneider Electric.
7. TORK.
8. Watt Stopper (The).
9. Lutron.

2.02 OUTDOOR PHOTOELECTRIC SWITCHES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Area Lighting Research, Inc.; Tyco Electronics.
   2. Grasslin Controls Corporation; a GE Industrial Systems Company.
   3. Intermatic, Inc.
   4. Lithonia Lighting, Sensor Switch
   5. Novitas, Inc.
   6. Paragon Electric Co.; Invensys Climate Controls.
   7. Square D; Schneider Electric.
   8. TORK.
   9. Touch-Plate, Inc.
   10. Watt Stopper (The).
   11. Lutron.

B. Description: Solid state, with DPST dry contacts rated for 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.
   1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.
   2. Time Delay: 15-second minimum, to prevent false operation.
   3. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.
   4. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

2.03 INDOOR PHOTOELECTRIC SWITCHES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Allen-Bradley/Rockwell Automation.
   2. Area Lighting Research, Inc.; Tyco Electronics.
   3. Eaton Electrical Inc; Cutler-Hammer Products.
   4. Grasslin Controls Corporation; a GE Industrial Systems Company.
   5. Intermatic, Inc.
   6. Lithonia Lighting, Sensor Switch
   7. MicroLite Lighting Control Systems.
   8. Novitas, Inc.
   9. Paragon Electric Co.; Invensys Climate Controls.
   10. Square D; Schneider Electric.

11. TORK.
12. Touch-Plate, Inc.
13. Watt Stopper (The).
14. Lutron.

B. Ceiling-Mounted Photoelectric Switch: Solid-state, light-level sensor unit, with separate relay unit mounted on luminaire, to detect changes in lighting levels that are perceived by the eye. Cadmium sulfide photoresistors are not acceptable.
1. Sensor Output: Contacts rated to operate the associated relay, complying with UL 773A. Sensor shall be powered from the relay unit.
2. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
3. Light-Level Monitoring Range: 10 to 200 fc (108 to 2152 lx), with an adjustment for turn- on and turn-off levels within that range.
4. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling, with deadband adjustment.
5. Indicator: Two LEDs to indicate the beginning of on-off cycles.

2.04 INDOOR OCCUPANCY SENSORS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Hubbell Lighting.
2. Leviton Mfg. Company Inc.
3. Lithonia Lighting, Sensor Switch
4. Novitas, Inc.
5. RAB Lighting, Inc.
6. Sensor Switch, Inc.
7. TORK.
8. Watt Stopper (The).
9. Lutron.

B. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.
1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 30 minutes.
2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
4. Mounting:
   a. Sensor: Suitable for mounting in any position on a standard outlet box.
   b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
   c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
6. Bypass Switch: Override the on function in case of sensor failure.
7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; keep lighting off when selected lighting level is present.

C. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.
1. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in.
2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.
3. Detection Coverage (Corridor): Detect occupancy within 90 feet when mounted on a 10- foot- high ceiling.

D. Ultrasonic Type: Ceiling mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage.
1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. when mounted on a 96-inch- high ceiling.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.
4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. when mounted on a 96-inch- high ceiling.
5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet when mounted on a 10-foot- high ceiling in a corridor not wider than 14 feet.

E. Dual-Technology Type: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be 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- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.

2.05 OUTDOOR MOTION SENSORS (PIR)

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Bryant Electric; a Hubbell Company.
2. Hubbell Lighting.

3. Lithonia Lighting, Sensor Switch
4. Paragon Electric Co.; Invensys Climate Controls.
5. RAB Lighting, Inc.
6. TORK.
7. Watt Stopper (The).
8. Lutron.

B. Performance Requirements: 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.
   1. Operation: Turn lights on when sensing infrared energy changes between background and moving body in area of coverage; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
   2. Mounting:
      a. Sensor: Suitable for mounting in any position on a standard outdoor junction box.
      b. Relay: Internally mounted in a standard weatherproof electrical enclosure.
      c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
   3. Bypass Switch: Override the on function in case of sensor failure.
   4. Automatic Light-Level Sensor: Adjustable from 1 to 20 fc; keep lighting off during daylight hours.

C. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in.

D. Detection Coverage: Up to 52.5 feet (16 m), with a field of view of 270 degrees

E. Lighting Fixture Mounted Sensor: Suitable for switching 1200 W of tungsten load at 120- or 277-V ac.

F. Individually Mounted Sensor: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
   1. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
   2. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.

2.06 LIGHTING CONTACTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Allen-Bradley/Rockwell Automation.
   2. ASCO Power Technologies, LP; a division of Emerson Electric Co.
   3. Eaton Electrical Inc.; Cutler-Hammer Products.
   4. GE Industrial Systems; Total Lighting Control.
   5. Grasslin Controls Corporation; a GE Industrial Systems Company.
   6. Hubbell Lighting.
   7. Lithonia Lighting, Sensor Switch
   8. MicroLite Lighting Control Systems.
   9. Square D; Schneider Electric.

10. TORK.
11. Touch-Plate, Inc.
12. Watt Stopper (The).
13. Lutron.

B. Description: Electrically operated and electrically held, combination type with fusible switch, complying with NEMA ICS 2 and UL 508.
   1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
   2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
   3. Enclosure: Comply with NEMA 250.
   4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

C. BAS Interface: Provide hardware interface to enable the BAS to monitor and control lighting contactors.
   1. Monitoring: On-off status.
   2. Control: On-off operation.

2.07 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 16 Section "Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG.

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 16 AWG.

3.00 EXECUTION

3.01 SENSOR INSTALLATION

A. 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.

3.02 CONTACTOR INSTALLATION

A. 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.

3.03 WIRING INSTALLATION

A. Wiring Method: Comply with Division 16 Section "Conductors and Cables." Minimum conduit size shall be 1/2 inch.

B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.04 IDENTIFICATION

A. Identify components and power and control wiring according to Division 16 Section "Electrical Identification."
   1. Identify controlled circuits in lighting contactors.
   2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.05 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
   2. Operational Test: Verify operation of each lighting control device, and adjust time delays.

B. Lighting control devices that fail tests and inspections are defective work.

3.06 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.07 DEMONSTRATION

A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system.

B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to Division 1 Section "Demonstration and Training."

END OF SECTION 16145

SECTION 16231
PACKAGED ENGINE GENERATOR

1.00 GENERAL

1.01 SCOPE OF WORK

A. Provide all labor, materials, and equipment to furnish and start-up the power generation system in accordance with the contract documents and manufacturer's drawings and installation instructions. These specifications also describe requirements for the design, fabrication, and testing of the power system.

B. The power generation system shall include the following:
   1. Engine-driven generator set.
   2. Control system, Cooling system.
   3. Fuel supply and storage system.
   4. Generator set accessories and Enclosure.

1.02 SYSTEM FUNCTION

A. The generator set shall include the capability of automatically controlling generator set operation. After starting, the unit will attain rated speed and voltage, and accept rated load. Generator set speed shall be controlled by the engine governor, while generator output voltage regulation shall be a function of the generator automatic voltage regulator.

1.03 SYSTEM PERFORMANCE

A. The power generating system shall conform to the following performance criteria:

B. Rating - Engine brake horsepower shall be sufficient to deliver full rated generator set kW/kVA when operated at rated rpm and equipped with all engine-mounted parasitic and external loads such as radiator fans and power generators.

C. Conditions - The rating shall be based on ISO 3046/1 standard conditions of 100 kPa and 27C (29.53 in Hg, 81F); BS 5514, DIN 6271, SAE J1349 and API 7B-11C also apply.

D. Fuel - Diesel engines shall be able to deliver rated power when operating on No. 2 diesel fuel having 35 degree API (16C, 60F) specific gravity.

E. Fuel Consumption - Diesel fuel rates shall be based on fuel having a low heating value (LHV) of 42,780 kJ/kg (18,390 Btu/lb) when used at 29C (85F) and weighing 838.9 g/l (7.001 lbs/U.S. gal).

F. Start Time and Load Acceptance - Engines shall start, achieve rated voltage and frequency, and be capable of accepting load within 10 seconds when properly equipped and maintained.

G. Block Load Acceptance - Transient response shall conform to ISO 8528 requirements.

1.04 PERFORMANCE

A. The individual generator set shall exhibit the following performance capability:

1.	At Site Conditions	
2.	Power Capability	1750 EkW Standby
3.	Speed	1800 RPM
4.	Cooling Type	Radiator, Blower fan, engine mounted
5.	Ambient Capability	125.0 Degree F
6.	Sound Level, Exhaust	85 dBA @ 10ft

1.05 RESPONSIBILITY

A. The responsibility for performance to this specification shall not be divided among individual component manufacturers, but must be assumed solely by the primary manufacturer. This includes generating system design, manufacture, test, and having a local supplier responsible for service, parts, and warranty for the total system.

1.06 PROTOTYPE TESTS

A. The system manufacturer must be able to certify that engine, generator, controls, and switchgear have been tested as complete systems of representative engineering models (not on equipment sold).

1.07 PRODUCTION TESTS

A. The system manufacturer shall perform post production tests on the generator set supplied. A certified report of these tests shall be available when requested at the time of the generator set order.

1.08 REFERENCES

A. This specification includes applicable considerations of:

1. American Society of Mechanical Engineers (ASME)
2. Association of British Generating Set Manufacturers (ABGSM)
3. British Standards Institution (BS)
4. EEC 89/392 Safety and Health
5. Electrical Generating Systems Association (EGSA)
6. Deutsches Institut fuer Normung (DIN)
7. Institute of Electrical and Electronics Engineers (IEEE)
8. International Electrotechnical Commission (IEC)
9. International Standards Organization (ISO) 9000
10. National Electrical Code (NEC)
11. National Electric Manufacturers Association (NEMA)
12. National Fire Protection Association (NFPA)
13. Occupational Safety and Health Act (OSHA)
14. Society of Automotive Engineers (SAE)
15. United States Military Standards for Generators and Controls(MIL-STD)

1.09 MINIMUM SERVICE AND WARRANTY QUALIFICATIONS

A. The manufacturer shall have a local authorized dealer who can provide factory trained servicemen, the required stock of replacement parts, technical assistance, and warranty administration.

1.10 WARRANTY ADMINISTRATION

A. The manufacturer's authorized dealer shall be capable of administering the manufacturer's and dealer's warranty for all components supplied by the selling dealer (who may or may not be the same as the servicing dealer).

1.11 WARRANTY TERMS

A. The manufacturer's and dealer's extended warranty shall in no event be for a period of less than five (5) years from date of initial start-up of the system and shall include repair parts, labor, reasonable travel expense necessary for repairs at the jobsite, and expendables (lubricating oil, filters, antifreeze, and other service items made unusable by the defect) used during the course of repair. Applicable deductible costs shall be specified in the manufacturer's warranty. Running hours shall not be a limiting factor for the system warranty by either the manufacturer or servicing dealer. Submittals received without written warranties as specified will be rejected in their entirety.

1.12 PARTS AVAILABILITY

A. The generator set supplier shall have sufficient parts inventory to maintain over the counter availability of at least 90% of any required parts.

1.13 OIL SAMPLING SERVICE

A. The generator set supplier shall provide a scheduled oil sampling service to monitor engine condition on an ongoing basis. The sampling method shall be of the atomic absorption spectrophometry method and be accurate to within a fraction of one part per million for the following elements.
   1. Iron
   2. Chromium
   3. Copper
   4. Aluminum
   5. Silicon
   6. Lead
   7. Water
   8. Fuel
   9. Antifreeze

B. The oil samples shall be analyzed at the generator set supplier's facility by factory trained personnel. Immediate notification of critical results shall be provided to the owner's representative.

1.14 SUMMARY

A. This Section includes packaged engine-generator sets for 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. Outdoor enclosure.

1.15 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

B. LP: Liquid petroleum.

1.16 SUBMITTALS

A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:
   1. Thermal damage curve for generator.
   2. Time-current characteristic curves for generator protective device.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
   2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
   4. Wiring Diagrams: Power, signal, and control wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that day tank, engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces defined in Division 16 Section "Electrical Supports and Seismic Restraints." 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.

D. Qualification Data: For manufacturer.

E. Source quality-control test reports.
   1. Certified summary of prototype-unit test report.

2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report of sound generation.
6. Report of exhaust emissions showing compliance with applicable regulations.
7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:
1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

H. Warranty: Special warranty specified in this Section.

1.17 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
1. Maintenance Proximity: Not more than four hours' normal travel time from Installer's place of business to Project site.
2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.

B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.

C. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL), and that is acceptable to authorities having jurisdiction.
1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

D. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

F. Comply with ASME B15.1.

G. Comply with NFPA 37.

H. Comply with NFPA 70.

I. Comply with NFPA 99.

J. Comply with NFPA 110 requirements for Level 1 emergency power supply system.
K. Comply with UL 2200.
L. Engine Exhaust Emissions: Comply with applicable state and local government requirements.
M. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.18 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 Owner's representative and Architect no fewer than two days in advance of proposed interruption of electrical service.
   2. Do not proceed with interruption of electrical service without Owner representative's and Architect's written permission.
B. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
   1. Ambient Temperature: 20 to 40 deg C.
   2. Relative Humidity: 0 to 100% percent.
   3. Altitude: 4.5 meters (15 feet) above sea level.
C. Unusual Service Conditions: Engine-generator equipment and installation are required to operate under the following conditions:
   1. Manila area black-out.
   2. Periods of strong wind such as typhoons – wind gust velocity up to 200 kilometers per hour.

1.19 COORDINATION

A. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.
B. Coordinate size and location of roof curbs, equipment supports, and roof penetrations for remote radiators. These items are specified in Division 7 Section "Roof Accessories."

1.20 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Five (5) years from date of final acceptance of the work.

1.21 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include

quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

1.22 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: 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.

2.00 PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with requirements, provide as manufactured by:
   1. Caterpillar Tractor Co.
   2. Covington Diesels.
   3. Cummins/Onan Engine Co., Inc.
   4. Kohler Co.

2.02 ENGINE GENERATOR SET

A. Factory-assembled and -tested, engine-generator set.
B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
   1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.
C. Capacities and Characteristics:
   1. Power Output Ratings: Nominal ratings as indicated.
   2. Output Connections: Three-phase, four wire.
   3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
D. Generator-Set Performance:
   1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
   2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
   3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
   4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.

5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: Comply with NFPA 110, Type 10, system requirements.

E. Generator-Set Performance for Sensitive Loads:
1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.
   a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.

8. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
   a. Provide permanent magnet excitation for power source to voltage regulator.
10. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.03 ENGINE

A. Engine Equipment:

1. The engine shall be equipped with air filters, fuel filters and pressure gauge, lubricating oil cooler, filters, and pressure gauge, water pump and temperature gauge, service hour meter, flywheel, and flywheel housing when applicable.

B. Structure/Metallurgy:

1. The design of the basic engine shall provide for maximum structural integrity to extend service life. Materials used in the engine shall incorporate the highest level of proven metallurgical and manufacturing technology. Block shall be of one piece design and cast of high tensile strength iron in the system manufacturer's own foundry. Counterboring for cylinder liners shall not be permitted. Crankshaft shall be a one piece forging with regrindable wear surfaces hardened through heat treat methods. Cylinder wear surfaces shall be induction hardened over their entire length. Main and rod bearings shall consist of aluminum bonded by copper to a steel backing. The wear surface shall be coated with a lead-tin overlay and the bearing covered by a tin flashing. Connecting rods shall be high strength steel with tapered pin bore. Drilled passages to supply oil from rod bearing for piston cooling and lubricating oil will not be permitted. Pistons shall be a lightweight aluminum alloy which is elliptically ground across the skirt and tapered from crown to skirt. High performance engines shall incorporate a two piece articulated piston with forged steel crown and cast aluminum skirt. For medium and high speed engines, compression rings in aluminum bodies shall have integral cast iron ring bands with keystone sectioned top rings. Compression rings in steel piston crowns shall seat in hardened steel grooves. Oil jets shall supply piston cooling and lubricating oil. Valves shall be hard-faced with replaceable inserts.

C. Lubrication System:

1. The lubrication oil pump shall be a positive displacement type that is integral with the engine and gear driven from the engine gear train. The system shall incorporate full flow filtration with bypass valve to continue lubrication in the event of filter clogging. The bypass valve must be integral with the engine filter base or receptacle. Systems where bypass valves are located in the replaceable oil filter are not acceptable. Pistons shall be oil cooled by continuous jet spray to the underside or inside of the crown and piston pin. The filter shall incorporate a self-lubricating, free rotating seal and have a nonmetallic core sufficiently rigid to minimize movement or shifting of the filtration media.

D. Diesel Fuel System:

1. The fuel system shall be integral with the engine. It shall consist of fuel filter, transfer pump, injection pumps, lines, and nozzles. The transfer pump shall deliver fuel under low pressure to individual injection pumps - one for each cylinder. The injection pumps shall be driven from the camshaft and simultaneously controlled by a rack and pinion assembly that is hydraulically actuated by signals from the engine governor. The pumps shall be of a variable displacement type to alter the volume of fuel delivered to the spray nozzles according to load demand. The nozzles shall inject fuel directly into the cylinder in the optimum spray pattern for efficient combustion.

E. Fuel Water System Separator

1. A fuel/water separator shall protect the fuel system from water damage.

F. Fuel Cooler

1. Fuel shall be piped from the filter/water separators to the intake of the engine fuel pump, and then to the engine. Excess fuel shall be piped through the fuel cooler and returned to the fuel tank with less than 60 kPa (8.7 PSI) restriction. The fuel cooler shall be capable of exchanging heat rejected at full load with the cooling medium, including 10% reserve to accommodate fouling.

G. Fuel Lines:

1. Flexible fuel lines between engine and fuel supply shall be installed to isolate vibration.

H. Governor-Electronic - Speed Control:

1. Speed droop shall be externally adjustable from 0 (isochronous) to 10% from no load to full rated load. Steady state frequency regulation shall be +/- 0.25 percent. Speed shall be sensed by a magnetic pickup off the engine flywheel ring gear. A provision for remote speed adjustment shall be included. In the event of a DC power loss, the forward acting actuator will move to the minimum fuel position.

I. Fan and Belt Guarding:

1. The fan, fan drive, and fan belts shall be covered with 14 gauge punched steel mesh guarding for personnel protection. The guarding shall conform to IEC 34-5, ISO and OSHA standards.

J. Blower Fan:

1. The radiator cooling fan shall be a blower type driven from the engine. Air shall be drawn from the engine side and exhausted through the radiator core.

K. Inlet Air System:

1. The engine air cleaner shall be engine mounted with dry element requiring replacement no more frequently than 250 operating hours or once each year. If external ducting is required, maximum restriction to the combustion air inlet shall be 6.7 kPa (27 in H2O) with air flow of 2988 cfm.

L. Turbo Charging:

1. Turbochargers shall be of the axial turbine type driven by engine exhaust gases and direct - connected to a compressor supplying engine combustion air.

M. After Cooling:

1. Aftercooler core air surfaces shall be coated with a corrosion inhibitor to minimize oxidation.

N. Exhaust System:

1. The engine exhaust system shall be installed to discharge combustion gases quickly and silently with minimum restriction. System including silencer shall be designed for minimum restriction, and in no case shall backpressure exceed 6.7 kPa (27 in H2O).

O. Silencer - Critical:

1. The silencer shall provide extreme noise attenuation for environments with low background noise and slight noise emissions would be objectionable.

P. Jacket Water Heater:

1. Jacket water heaters shall be provided to maintain coolant temperature of 32C (90F) while the engine is idle. Heaters shall accept 208 volt AC single phase power and include thermostatic controls. Hoses to and from the heater shall be industrial quality which exhibit long life in operational environments. Manual shutoff valves shall be incorporated to isolate the heater during servicing. The JWH shall be dual 3 kW heaters for a total of 6 kW.

Q. Batteries:

1. Batteries for starting and control shall be selected and supplied by the generator set manufacturer. They shall be a heavy duty SLI lead acid type with thru-partition connectors, and housed in a hard rubber or polypropylene case with provision for venting. Starting batteries shall be rated 24 volt DC with a minimum of 280 ampere-hour and 2000 CCA. Sizing shall consider specific application requirements of engine oil viscosity, ambient starting temperature, control voltage, overcharging and vibration. Batteries shall be located as close to the starting motor as practical, away from spark sources, in a relatively cool ambient, and permit easy inspection and maintenance. Battery warranty shall be the responsibility of the generator set manufacturer.

R. Alternator:

1. An engine mounted belt driven battery charging alternator shall be installed with an automatic voltage regulator. It shall be suitable for heavy duty applications with a rating of 24 volts, 35 amperes.

S. Fuel: Fuel oil, Grade DF-2.

T. Rated Engine Speed: 1800 rpm.

U. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm.

V. 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.

W. Engine Fuel System:

1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
3. Dual Natural Gas with LP-Gas Backup (Vapor-Withdrawal) System:
   a. Carburetor.
   b. Secondary Gas Regulators: One for each fuel type.
   c. Fuel-Shutoff Solenoid Valves: One for each fuel source.
   d. Flexible Fuel Connectors: One for each fuel source.

X. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.

Y. Governor: Adjustable isochronous, with speed sensing.

Z. 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.

AA. 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. Muffler/Silencer shall be located within enclosure.

BB. Starting System: 24-V electric, with negative ground.

1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.

2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: As required by NFPA 110 for system level specified.
4. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least three times without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.
7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:
   a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
   b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
   c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
   d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
   e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
   f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.04 GENERATOR

A. General:

1. The generators shall be rated for Standby service at 1750 kW, 2187.5 kVA, 0.8 PF, 480/277 V, three phase, 4 wire, 60 Hz, 1800 rpm.
2. The generator shall be capable of withstanding a three phase load of 300% rated current for 10 seconds, and sustaining 150% of continuous load current for 2

minutes with field set for normal rated load excitation. It shall exhibit less than 5% waveform deviation at no load.

3. Generator efficiencies shall be calculated according to IEC 34-2 Section 4, with all I2R losses corrected to 115C.

B. Mechanical Design - Single Bearing:

1. The generator housing shall be one piece and mount directly to the engine flywheel housing without bolted adaptors. Engine torque shall be transmitted through flexible steel plates to the generator rotor. The generator ventilating fan shall mount to the engine flywheel and act as a pressure plate to secure the flexible plates. The rotor core shall be constructed of low loss non-orientated steel laminations attached to the core lengths and fitted with low resistance amortisseur bars brazed/welded to plates at both ends of the core. The rotor assembly shall demonstrate 150% overspeed capability at 170C for 2 hours. Rotor dynamic, two plane balance shall not exceed 0.002 inch peak to peak amplitude at operating speed. All rotating components shall be secured with SAE Grade 8 hardware. C. Windings:

2. Windings shall be form wound. Thermal Class 200 magnet wire as described by NEMA Magnet Wire Standard MW 1000, Section MW 35-C, shall be used for rotor and stator windings. The windings shall consist of copper magnet wire coated with an underlay of polyester resins and a superimposed heavy coat of polyamideimide resins. All winding insulation shall be Class H in accordance with BS and IEEE standards. No materials shall be used which support fungus growth, and shall be impervious to oil, dirt and fumes encountered in diesel operating conditions.

D. Operating Environment:

1. The generator shall be designed to operate in a sheltered drip-proof environment. Generator shall be equipped with 120 volt AC single phase space heaters to minimize condensation while the generator set is idle. The heaters shall be capable of easily mounting in the assembled generator.

E. Excitation:

1. The generator exciter shall be brushless with the circuit consisting of a three-phase armature and a three-phase full wave bridge rectifier mounted on the rotor shaft. Surge suppressors shall be included to protect the rotating diodes from voltage spikes. The permanent magnet excitation system shall derive excitation current from a pilot exciter mounted on the rotor shaft. It shall enable the generator to sustain 300% of rated current for ten seconds during a fault condition.

F. Voltage Regulator:

1. The automatic voltage regulator shall maintain generator output voltage by controlling the current applied to the exciter field of the generator. The regulator shall be a totally solid state design which includes electronic voltage buildup and overcurrent protection. It shall incorporate 1:1 volts per Hertz characteristics with the regulated voltage a linear function proportional to frequency over a 30 to 70 Hz range. The regulator shall be

suitable for mounting within or external to the generator assembly, and have provision for remote voltage level control, using 16 ga shielded wire. As installed, the voltage regulator shall meet the applicable sections of the following standards:

a. Canadian Standards Association (CSA)
b. International Electrotechnical Commission (IEC)
c. Institute of Electrical and Electronic Engineers (IEEE)
d. National Electrical Manufacturers Association (NEMA)

G. Voltage Regulator - Digital:

1. The digital voltage regulator shall be microprocessor based with fully programmable operating and protection characteristics. The regulator shall be capable of sensing true RMS in three phases of generator output voltage, or operating in single phase sensing mode. It shall exhibit the following operational characteristics:
   a. Generator output voltage maintained within +/- 0.25% at steady state conditions.
   b. Generator output voltage maintained within +/- 0.25% of rated value for any load variation between no load and full load.
   c. Generator output voltage drift no more than +/-0.25% of rated value at constant temperature.
   d. Generator output voltage drift no more than +/- 0.5% of rated value within a 40 change over ambient temperature range of -40C to 70C.
   e. Response time less than 20 millisecond.
   f. Voltage buildup with generator output as low as 6 volts.
   g. At full throttle engine starting, output voltage overshoot no more than 5% of its rated value, with respect to the volts/Hz curve. Meets ISO 8325-3 class G2 specifications.
   h. Power dissipation 55 W at 15 amps; <100 ma at rest.
   i. Telephone Influence Factor (TIF) of less than 50.
   j. Electronic Interference/Radio Frequency Interference (EMI/RFI) suppressed to MIL STD 461C Part 9 and VDE 875 level N.
   k. Maintain stable voltage control with 20% total harmonic distortion.
   l. The regulator shall include the following features:
   m. Voltage level rheostat to provide generator output voltage adjustment of -10% to +10% of nominal. This shall be in addition to a programmable output voltage level of -25% to +10%
   n. Automatic gain adjustment to provide output voltage compensation for changes in load or frequency.
   o. Manual gain adjustment 0 - 10% to provide compensation for line losses between generator output terminals and the load.
   p. Reactive droop adjustment programmable to allow paralleling without interconnect wiring between generators, with 10% minimum droop at full load and 0.8 PF.
2. It shall allow system parameter setup and monitoring, and provide fault alarm and shutdown information through a keyed LCD display. A PC-based user interface shall be available to allow viewing and modifying operating parameters in a windowed environment. The regulator shall be factory preset but field programmable for: voltage output; voltage, minimum; voltage droop/crosscurrent adjustment; voltage gain (IR

compensation); voltage gain, internal; current, output; field current variation; sensing, single or three phase; dual voltage/frequency slopes; slope intersect (knee) frequency; underfrequency setpoint; over/under voltage trip; over/under voltage trip time. Protection shall be provided for the regulator against long term overcurrent conditions. Generator output shall shut off when output is shorted, or excitation current exceeds normal for 15 seconds. The regulator shall not be damaged or result in unsafe operation when subjected to open or shorted input due to sensing loss, or sensing source shorted to ground or adjacent conductor. The regulator shall be capable of operating while mounted within the generator assembly, or 300m (985 ft) from the generator. It shall have rovision for remote voltage level control, using 16 ga shielded wire. The regulator module sealed in a waterproof and airtight shock resistant plastic housing and shall withstand:

a. Operating temperatures between -40C to 70C. b. Shock tolerance to 20 g's
c. Vibration of 4.5 g's (peak) between frequencies of 18 to 2000
d. Hz in three perpendicular planes, and mechanical shock of 15 g's in all three planes.
e. Salt spray resistant as described by MIL STD-810C, Method 509.1 and ASTM-B117.
f. Pressure sealed to withstand 35 kPa (5 PSI).
g. The regulator shall be manufactured by the manufacturer of the engine-generator set.

H. Mounting:

1. The engine and generator shall be assembled to a common base by the engine-generator manufacturer. The generator set base shall be designed and built by the engine-generator manufacturer to resist deflection, maintain alignment, and minimize resonant linear vibration.

I. Isolator - Spring Type:

1. Steel spring isolators shall be installed between the generator set base and the mounting surface. The isolators shall bolt to the base, and have a waffled or ribbed pad on their bottom surface. The pads shall be resistant to heat and age, and impervious to oil, water, antifreeze, diesel fuel, and cleaning compounds.

J. Controls, Protection, and Monitoring:

1. The controls, protection, and monitoring systems of the generator set and its operation shall be the responsibility of the generator set manufacturer. All subsystem components, interfaces, and logic shall be compatible with engine mounted devices.

2.05 CONTROLS - GENERATOR SET MOUNTED

A. The control panel shall be designed and built by the engine-generator manufacturer. It shall be mounted on the generator set and incorporate 100% solid state microprocessor based control circuitry and digital instrumentation. All electronic control components are to be mounted in sealed, dust tight, watertight, metal housings. Housings which must be opened for service or setup are not acceptable. All output circuits greater than 100mA shall be fuse or circuit breaker protected. The panel shall be labeled with ISO symbols and comply with IEC 144, IP 22, and

NEMA 12 for external environmental resistance, and IP 44 and NEMA 12 for resistance of the internal sealed modules. The control panel shall be capable of facing the right, left, or rear and shall be vibration isolated.

B. The panel shall include the following equipment / functions:
   1. Automatic remote start capability with mode of operation selectable from a panel-mounted 4-position switch (Stop, Manual, Automatic, Reset).
   2. Cycle crank with adjustable "crank" and "rest" times.
   3. Adjustable cooldown timer.
   4. Emergency Stop push button requiring manual reset.
   5. Voltage adjustment potentiometer to adjust voltage +10, -25% of rated.
   6. Individual flashing LED's shall be provided.

C. The use of a common alarm or shutdown lamp which depend on a separate display to determine the alarm or fault condition is not acceptable.

D. Separate LED annunciation shall be provided for:
   1. Overspeed (red)
   2. Overcrank (red)
   3. High Coolant temperature (red)
   4. Low Oil pressure (red)
   5. Emergency Stop (red)
   6. Low Coolant Level (red - programmable as alarm or shutdown)

E. NFPA 99 alarm module with common alarm and silence switch shall be located in the control panel.

F. Panel illumination lights (2) with ON/OFF switch shall be provided on the control panel.

G. Separate digital displays shall be provided for the engine and generator parameters. These displays shall allow the simultaneous display of AC parameters and at least one (selectable) engine parameter to be displayed at the same time. Requirements for these displays are as follows:
   1. Digital display and phase selector switch for generator operational parameters. True RMS sensing of these parameters shall be utilized to minimize distortion due to non-linear loads and ensure accuracy.
   2. AC volts (+/- 0.5% accuracy)
   3. AC amps (+/- 0.5% accuracy)
   4. Hertz (+/- 0.3 Hz accuracy)

H. Digital display for:
   1. Engine RPM (+/- 0.5% accuracy)
   2. DC voltage (+/- 0.5% accuracy)
   3. Oil pressure (+/- 0.5% accuracy)
   4. Coolant temperature (+/- 0.5% accuracy)
   5. Operating hours

I. Diagnostic capability:

1. Must provide dual level diagnostics identifying both system level and component level. The diagnostic codes shall be maintained in a history log specifying the number of occurrences, and second/minute/hr at which they occur.

J. Sensors:

1. Sensors providing a pulse with modulated output shall be utilized for oil pressure, coolant temperature sensing and shall be protected against a fault to (+/-) battery. The usable output range of the sensor shall be limited to 5% to 95% duty cycle. Output outside the usable range shall be diagnosed as a fault condition and appropriate diagnostic shall be provided. Separate speed sensing signals shall be provided for overspeed protection and electronic governing.

K. Ambient parameters:

1. Operating: -40C to +70C (-40 F to +158 F)
2. Storage: -55 C to +85 C (-67 F to +185 F)
3. Humidity: 0 to 100% relative humidity

L. Must be impervious to salt spray, fuel, oil and oil additives, coolant, spray cleaners, chlorinated solvents, hydrogen sulfide and methane gas, and dust.

2.06 CIRCUIT BREAKER - GENERATOR SET MOUNTED

A. The main line circuit breakers shall be mounted and connected in a guarded dripproof enclosures meeting NEMA 1, IP 22 and IEC 144. The circuit breakers shall be 100% rated and sized as indicated on the drawings. Each circuit breaker shall meet or exceed the minimum short circuit rating of the equipment it feeds.

2.07 BACK-UP LIGHTING

A. Lighting with battery back-up shall be provided inside the generator housing for maintenance personnel to trouble-shoot if the generator fails to start.

2.08 BATTERY CHARGER

A. A dual rate 10 ampere battery charger shall be provided which shall accept 120 volt AC single phase input to provide 24 volt DC output. It shall be fused on the AC input and DC output, and incorporate current limiting circuitry to avoid the need for a crank disconnect relay. An AC voltage power switch shall be mounted on the face of the charger and shielded from accidental switching. The charger shall include an AC ammeter and voltmeter, a failure malfunction alarm switch, and be housed in a NEMA 1 enclosure suitable for wall mounting.

2.09 RADIATOR

A. The engine cooling system shall be treated by the engine supplier for the inhibition of internal corrosion using Nalcool 2000 rust inhibitor per the manufacturer's formulas for a properly treated cooling system.

2.10 ENCLOSURE

A. Provide a rust resistant weather-protective housing for diesel generator unit made of heavy gauge reinforced steel; mate and match to the unit enclosed, which permits proper cooling and access to both controller and service points.

2.11 WEIGHT

A. The weight of the engine unit consisting of generator set, base and all other specified items including all liquids (i.e., fuel oil, lube oil and cooling solutions) shall be calculated by the engine dealer utilizing manufacturer's data. The base of the unit shall be designed and manufactured as a heavy duty, structural steel construction with four point lifting provisions to support the calculated weight. Details and manufacturer's certification of the base construction shall be included with the drawings submitted for approval as well as all dealer weight calculations supported by manufacturer's data.

2.12 FUEL TREATMENT

A. Provide fuel treatment that is a detergent, dispersant, biocide, demulsifier, corrosion inhibitor, metal deactivator, polymerization retardant, and pour point reducer. Install at dosage ratio recommended by manufacturer. Additive shall be International Lubrication and Fuel Consultants Inc. #1052, or pre-approved equal.

2.13 TAIL PIPE

A. Each silencer shall be fitted with a 90 degree tail pipe extension (elbow) terminating in a vertical position and, to prevent the entrance of rain water, shall be fitted with a weighted, aluminum rain cap. The exhaust stacks will extend up to above the adjacent Mechanical Room roofline.

2.14 FUEL OIL STORAGE

A. Comply with NFPA 30.

B. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:

1. Tank level indicator.
2. Capacity: Fuel for twenty-four (24hours' continuous operation at 100 percent rated power output.
3. Vandal-resistant fill cap.
4. Containment Provisions: Comply with requirements of authorities having jurisdiction.
5. Fuel Oil Tank shall be contained within footprint of Generator.

2.15 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or

derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.

D. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel.

E. 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 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 Division 16 Section "Switchboards."
3. Switchgear Construction: Freestanding unit complying with Division 16 Section "Switchgear."
4. Current and Potential Transformers: Instrument accuracy class.

F. Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 1 system, and the following:

1. AC voltmeter.
2. AC ammeter.
3. AC frequency meter.
4. DC voltmeter (alternator battery charging).
5. Engine-coolant temperature gage.
6. Engine lubricating-oil pressure gage.
7. Running-time meter.
8. Ammeter-voltmeter, phase-selector switch(es).
9. Generator-voltage adjusting rheostat.
10. Fuel tank derangement alarm.
11. Fuel tank high-level shutdown of fuel supply alarm.
12. Generator overload.

G. Indicating and Protective Devices and Controls:

1. AC voltmeter.
2. AC ammeter.
3. AC frequency meter.
4. DC voltmeter (alternator battery charging).
5. Engine-coolant temperature gage.
6. Engine lubricating-oil pressure gage.
7. Running-time meter.
8. Ammeter-voltmeter, phase-selector switch(es).
9. Generator-voltage adjusting rheostat.
10. Start-stop switch.
11. Overspeed shutdown device.
12. Coolant high-temperature shutdown device.
13. Coolant low-level shutdown device.
14. Oil low-pressure shutdown device.
15. Fuel tank derangement alarm.
16. Fuel tank high-level shutdown of fuel supply alarm.
17. Generator overload.

H. 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.

I. Connection to Data Link: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of

indications to remote data terminals. Data system connections to terminals are covered in Division 16 Section "Electrical Power Monitoring and Control."

J. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.
   1. Overcrank shutdown.
   2. Coolant low-temperature alarm.
   3. Control switch not in auto position.
   4. Battery-charger malfunction alarm.
   5. Battery low-voltage alarm.

K. Common Remote Audible Alarm: Signal the occurrence of any events listed below without differentiating between event types. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset.
   1. Engine high-temperature shutdown.
   2. Lube-oil, low-pressure shutdown.
   3. Overspeed shutdown.
   4. Remote emergency-stop shutdown.
   5. Engine high-temperature prealarm.
   6. Lube-oil, low-pressure prealarm.
   7. Fuel tank, low-fuel level.
   8. Low coolant level.

L. 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.

M. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.16 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. 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.

B. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector shall perform the following functions:

2.17 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

F. Enclosure: Dripproof.

G. Instrument Transformers: Mounted within generator enclosure.

H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
   1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.

I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding. K. Subtransient Reactance: 12 percent, maximum.

2.18 OUTDOOR GENERATOR-SET ENCLOSURE

A. Description: Vandal-resistant, weatherproof steel housing, wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

B. Description: Prefabricated or preengineered walk-in enclosure with the following features:
   1. Construction: Galvanized-steel, metal-clad, integral structural-steel-framed building erected on concrete foundation.
   2. Structural Design and Anchorage: Comply with ASCE 7 for wind loads.
   3. Space Heater: Thermostatically controlled and sized to prevent condensation.
   4. Louvers: Equipped with bird screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust, birds, and rodents.
   5. Hinged Doors: With padlocking provisions.
   6. Ventilation: Louvers equipped with bird screen and filter arranged to permit air circulation while excluding exterior dust, birds, and rodents.
   7. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine-generator-set components.
   8. Muffler Location: Within enclosure.

C. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.

1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.

D. Interior Lights with Switch: Factory-wired, vaporproof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.

1. AC lighting system and connection point for operation when remote source is available.
2. DC lighting system for operation when remote source and generator are both unavailable.

E. Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.

F. Panelboard: Single point connection for the enclosure, 100A main, 208/120V, 3-Phase, 4-Wire, 60Hz. This panelboard feed the loads in the generator enclosure. Minimum 4 – 20 circuit breakers shall be provided for future loads.

2.20 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.
2. Durometer Rating: 30.
3. Number of Layers: Two.

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 ¼ inch thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.21 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.22 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
2. Full load run.
3. Maximum power.
4. Voltage regulation.
5. Transient and steady-state governing.
6. Single-step load pickup.
7. Safety shutdown.
8. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
9. Report factory test results within 10 days of completion of test.

3.00 EXECUTION

3.01 TESTING

A. Test diesel generator set in accordance with Section 16015 Testing and Placing in Service.
B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.02 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.
B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.03 INSTALLATION

A. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

B. Install packaged engine generator with restrained spring isolators having a minimum deflection of 1 inch on 4 inch high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Division 16 Section "Electrical Supports and Seismic Restraints."

C. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet. Flexible

connectors and steel piping materials and installation requirements are specified in Division 15 Section "Hydronic Piping."

1. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints. Flexible connectors and piping materials and installation requirements are specified in Division 15 Section "Hydronic Piping."

D. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

E. Installation of Diesel Engine Driven Generator Sets:

1. Install diesel engine driven generator as indicated, in accordance with the equipment manufacturer's written instructions, and with recognized industry practices, to ensure that engine generator units fulfill requirements. Comply with NFPA 110 and NEMA standards pertaining to installation of engine generator sets and accessories.
2. Coordinate with other work, including raceways, electrical boxes and fittings, fuel tank, piping and accessories, as necessary to interface installation of engine generator equipment work with other work.
3. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Stds 486A, B and the National Electrical Code.
4. Install units on vibration isolators in accordance with manufacturer's indicated method of installation.
5. Connect fuel oil piping to fuel tank as indicated, and comply with manufacturer's installation instructions.
6. Align shafts of engine and generator within tolerances recommended by engine generator unit manufacturer.
7. Post-Installation Testing:
   a. Following installation, the following tests shall be performed by the system manufacturer's local dealer representative (s) in the presence of the owner's engineer or designated appointee:

3.04 CONNECTIONS

A. Piping installation requirements are specified in Division 15 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 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 outside the building are specified in Division 2 Section "Fuel Oil Distribution."

2. Diesel fuel piping, valves, and specialties inside the building are specified in Division 15 Section "Fuel Oil Piping."
3. Natural- and LP-gas piping, valves, and specialties for gas distribution outside the building are specified in Division 2 Section "Natural Gas Distribution."
4. Natural- and LP-gas piping, valves, and specialties for gas piping inside the building are specified in Division 15 Section "Fuel Gas Piping."

F. Ground equipment according to Division 16 Section "Grounding and Bonding." G. Connect wiring according to Division 16 Section "Conductors and Cables."

3.05 IDENTIFICATION

A. Identify system components according to Division 15 Section "Mechanical Identification" and Division 16 Section "Electrical Identification."

3.06 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. Report results in writing.

B. 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.

C. Tests and Inspections:
   1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
   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 under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
10. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.
11. Prestart Checks:
    a. Oil level; water level; sub-base tank fuel level; battery connection and charge condition; engine to control interconnects; engine generator intake/exhaust obstructions.
12. Operation:
    a. Load - One-hour operation at 80% of full load rating. Two hours operation at 100% of full load rating. After the first half-hour stabilization period at full load, the following shall be recorded at fifteen minute intervals:
        1) Voltage and amperage (3 phase), frequency
        2) Fuel pressure, oil pressure and water temperature
        3) Exhaust gas temperature at engine exhaust outlet
        4) Ambient temperature
    b. Proper operation of controls, engine shutdown, and safety devices shall be demonstrated.
    c. The manufacturer's representative shall provide inductive load banks and field engineer for the test. Building load shall not be used.

D. Coordinate tests with tests for transfer switches and run them concurrently.

E. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.

F. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

G. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

H. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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

J. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

K. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

L. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.
   1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.
   2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.07 DEMONSTRATION

A. The system manufacturer's authorized dealer shall provide a complete orientation for the owner's engineering and maintenance personnel. Orientation shall include both classroom and hands-on instruction. Topics covered shall include control operation, schematics, wiring diagrams, meters, indicators, warning lights, shutdown system and routine maintenance.

B. Fuel:
   1. Provide full tanks of diesel fuel, after all testing and startup.

END OF SECTION 16231

SECTION 16269
VARIABLE FREQUENCY CONTROLLERS

1.00 GENERAL

1.01 SCOPE OF WORK

A. This Section includes solid-state, PWM, VFCs, for speed control of three-phase, squirrel-cage induction motors.

B. Related Sections include the following:

1. Division 16 Section "Electrical Power Monitoring and Control" for monitoring and control of motor circuits.
2. Division 16 Section "Transient Voltage Suppression" for low-voltage power, control, and communication surge suppressors.

1.02 DEFINITIONS

A. BMS: Building management system.
B. IGBT: Integrated gate bipolar transistor.
C. LAN: Local area network.
D. PID: Control action, proportional plus integral plus derivative.
E. PWM: Pulse-width modulated.
F. VFC: Variable frequency controller.

1.03 SUBMITTALS

A. Product Data: For each type of VFC. Include dimensions, mounting arrangements, location for conduit entries, shipping and operating weights, and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.

B. Shop Drawings: For each VFC.

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. Include the following:
   a. Each installed unit's type and details.
   b. Nameplate legends.
   c. Short-circuit current rating of integrated unit.
   d. Features, characteristics, ratings, and factory settings of each motor-control center unit.
2. Wiring Diagrams: Power, signal, and control wiring for VFCs. Provide schematic wiring diagram for each type of VFC.

C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs where pipe and ducts are prohibited. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Qualification Data: For manufacturer.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For VFCs, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for VFCs and all installed components.
2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

G. 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.

H. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Source Limitations: Obtain VFCs of a single type through one source from a single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with NFPA 70.

E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, minimum clearances between VFCs, and adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver VFCs in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.

B. Store VFCs indoors in clean, dry space with uniform temperature to prevent condensation. Protect VFCs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. If stored in areas subject to weather, cover VFCs to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

1.06 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions, unless otherwise indicated:

1. Ambient Temperature: 20 to 40 deg C.
2. Humidity: Less than 90 percent (noncondensing).
3. Altitude: Not exceeding 100 meters (330 feet).

B. Interruption of 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 Owner's representative and Project Architect/Engineer no fewer than days in advance of proposed interruption of electrical service.
2. Indicate method of providing temporary electrical service.
3. Do not proceed with interruption of electrical service without Architect's written permission.

C. Product Selection for Restricted Space: Shop drawings shall indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.07 COORDINATION

A. Coordinate layout and installation of VFCs 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 size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

D. Coordinate features of VFCs, installed units, and accessory devices with pilot devices and control circuits to which they connect.

E. Coordinate features, accessories, and functions of each VFC and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.08 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Spare Fuses: Furnish one spare for every five installed, but no fewer than two sets of each type and rating.
2. Indicating Lights: Two of each type installed.

2.00 PRODUCTS

2.01 MANUFACTURERS

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

1. Danfoss Inc.; Danfoss Electronic Drives Div.
2. Eaton Corporation; Cutler-Hammer Products.
3. Siemens Energy and Automation; Industrial Products Division.
4. Square D.

2.02 SEQUENCE OF OPERATION

A. Refer to Section 15958 – BAS Sequence of Operation

2.03 VARIABLE FREQUENCY CONTROLLERS

A. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.

1. Provide unit suitable for operation of premium-efficiency motor as defined by NEMA MG 1.

B. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

C. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.

D. Unit Operating Requirements:

1. Input ac voltage tolerance of 380 to 500 V, plus or minus 10 percent.
2. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.
3. Minimum Efficiency: 96 percent at 60 Hz, full load.
4. Minimum Displacement Primary-Side Power Factor: 96 percent.
5. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
6. Starting Torque: 100 percent of rated torque unless noted otherwise.
7. Speed Regulation: Plus or minus 1 percent.

E. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.

1. Electrical Signal: 4 to 20 mA at 24 V.
2. Pneumatic Signal: 3 to 15 psig (20 to 104 kPa).

F. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 2 to a minimum of 22 seconds.
4. Deceleration: 2 to a minimum of 22 seconds.
5. Current Limit: 50 to a minimum of 110 percent of maximum rating.

G. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors.
2. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
3. Motor Overload Relay: Adjustable and capable of NEMA ICS 2, Class 20 performance.
4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
5. Instantaneous line-to-line and line-to-ground overcurrent trips.
6. Loss-of-phase protection.
7. Reverse-phase protection.
8. Short-circuit protection.
9. Motor overtemperature fault.

H. Multiple-Motor Capability: Controller suitable for service to multiple motors and having a separate overload relay and protection for each controlled motor. Overload relay shall shut off controller and motors served by it when overload relay is tripped.

I. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

J. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.

K. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

L. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

M. Input Line Conditioning: Provide for drives serving motors greater than 20 HP.

N. VFC Output Filtering: Provide for drives serving motors greater than 20 HP.

O. Status Lights: Door-mounted LED indicators shall indicate the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

P. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.

Q. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (VDC).
9. Set-point frequency (Hz).
10. Motor output voltage (V).

R. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
2. Pneumatic Input Signal Interface: 3 to 15 psig.
3. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:
   a. 0 to 10-V dc.
   b. 0-20 or 4-20 mA.
   c. Potentiometer using up/down digital inputs.
   d. Fixed frequencies using digital inputs.
   e. RS485.
   f. Keypad display for local hand operation.
4. Output Signal Interface:
   a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
      1) Output frequency (Hz).
      2) Output current (load).
      3) DC-link voltage (VDC).
      4) Motor torque (percent).
      5) Motor speed (rpm).
      6) Set-point frequency (Hz).
5. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
   a. Motor running.
   b. Set-point speed reached.
   c. Fault and warning indication (overtemperature or overcurrent).
   d. PID high- or low-speed limits reached.

S. Miscellaneous Signal Interface:

1. Two (2) output auxiliary contacts: 1-N.O and 1-N.C. (120-V ac, 5 A)
2. Two (2) input interlock / permissive: 1-N.O and 1-N.C.

T. Communications: Provide an interface compatible with the BMS system allowing VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via BMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.

U. Manual Bypass: Magnetic contactor arranged to safely transfer motor between controller output and bypass controller circuit when motor is at zero speed. Controller-off-bypass selector switch sets mode, and indicator lights give indication of mode selected. Unit shall be capable of stable operation (starting, stopping, and running), with motor completely disconnected from controller (no load).

V. Bypass Controller: NEMA ICS 2, full-voltage, nonreversing enclosed controller with across-the- line starting capability in manual-bypass mode. Provide motor overload protection under both modes of operation with control logic that allows common start-stop capability in either mode.

W. Integral Disconnecting Means: NEMA AB 1, instantaneous-trip circuit breaker with lockable handle.

X. Isolating Switch: Non-load-break switch arranged to isolate VFC and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.

Y. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

2.04 ENCLOSURES

A. NEMA 1 unless otherwise noted.

2.05 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory- applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

D. Control Relays: Auxiliary and adjustable time-delay relays.

E. Standard Displays:

1. Output frequency (Hz).
2. Set-point frequency (Hz).
3. Motor current (amperes).
4. DC-link voltage (VDC).
5. Motor torque (percent).
6. Motor speed (rpm).
7. Motor output voltage (V).

F. Historical Logging Information and Displays:

1. Real-time clock with current time and date.

2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

G. Current-Sensing, Phase-Failure Relays for Bypass Controller: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage; with adjustable response delay.

2.06 FACTORY FINISHES

A. Finish: Manufacturer's standard Insert color paint applied to factory-assembled and tested VFCs before shipping.

3.00 EXECUTION

3.01 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

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

3.04 APPLICATIONS

A. Select features of each VFC to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller, and load. Short circuit rating of each VFC is to be equal to or greater than the short circuit rating of the panelboard or switchboard serving the VFC.

B. Select horsepower rating of controllers to suit motor controlled.

3.03 INSTALLATION

A. Anchor each VFC assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with mounting surface.

B. Install VFCs on concrete bases.

C. Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 16 Section "Fuses."

3.04 CONCRETE BASES

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

B. Concrete base is specified in Division 16 Section "Basic Electrical Materials and Methods," and concrete materials and installation requirements are specified in Division 3 “Cast-in-Place” Concrete.

3.05 IDENTIFICATION

A. Identify VFCs, components, and control wiring according to Division 16 Section "Electrical Identification."

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.06 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices according to Division 16 Section "Conductors and Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switch and other automatic-control devices where applicable.

1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
2. Connect selector switches with control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.07 CONNECTIONS

A. Conduit installation requirements are specified in other Division 16 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment according to Division 16 "Grounding and Bonding."

3.08 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each enclosed controller element, 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 controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Assist in field testing of equipment including pretesting and adjusting of solid-state controllers.
3. Report results in writing.

C. Perform the following field tests and inspections and prepare test reports:

1. Provide for factory authorized technicians to perform testing according to the manufacturer's recommendations.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.09 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain variable frequency controllers. Refer to Division 1 Section "Demonstration and Training."

END OF SECTION 16269

SECTION 16289
TRANSIENT VOLTAGE SUPPRESSION

1.00 GENERAL

1.01 SCOPE OF WORK

A. This Section includes TVSSs for low-voltage power, control, and communication equipment.

B. Related Sections include the following:

1. Division 16 Section "Wiring Devices" for devices with integral TVSSs.
2. Division 16 Section "Switchboards" for factory-installed TVSSs.
3. Division 16 Section "Panelboards" for factory-installed TVSSs.

1.03 DEFINITIONS

A. SVR: Suppressed voltage rating.

B. TVSS: Transient voltage surge suppressor.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating weights, operating characteristics, furnished specialties, and accessories.

B. Product Certificates: For transient voltage suppression devices, signed by product manufacturer certifying compliance with the following standards:

1. UL 1283.
2. UL 1449.

C. Operation and Maintenance Data: For transient voltage suppression devices to include in emergency, operation, and maintenance manuals.

D. Warranties: Special warranties specified in this Section.

1.05 QUALITY ASSURANCE

A. Source Limitations: Obtain suppression devices and accessories through one source from a single manufacturer.

B. Product Options: Drawings indicate size, dimensional requirements, and electrical performance of suppressors and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with IEEE C62.41, "IEEE Guide for Surge Voltages in Low Voltage AC Power Circuits," and test devices according to IEEE C62.45, "IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits."

E. Comply with NEMA LS 1, "Low Voltage Surge Protection Devices."

F. Comply with UL 1283, "Electromagnetic Interference Filters," and UL 1449, "Transient Voltage Surge Suppressors."

1.06 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Owner's representative and Project Architect/Engineer not less than two days in advance of proposed utility interruptions.

2. Do not proceed with utility interruptions without Owner representatives written permission.

B. Service Conditions: Rate surge protection devices for continuous operation under the following conditions, unless otherwise indicated:
1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
2. Operating Temperature: 30 to 120 deg F.
3. Humidity: 0 to 90 percent, noncondensing.
4. Altitude: Less than 20,000 feet above sea level.

1.07 COORDINATION

A. Coordinate location of field-mounted surge suppressors to allow adequate clearances for maintenance.

B. Coordinate surge protection devices with Division 16 Section "Electrical Power Monitoring and Control."

1.08 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within five years from date of Substantial Completion.

1.09 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Replaceable Protection Modules: One of each size and type installed.
2. One hand-held analyzer.

2.00 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Liebert
2. LEA International.
3. Siemens Energy & Automation, Inc.
4. Thor Systems

2.02 SURGE SUPPRESSOR DEVICE

A. Surge Protection Device Description: Modular design with field-replaceable modules, sine- wave-tracking type with the following features and accessories:
   1. Fuses, rated at 200-kA interrupting capacity.
   2. Fabrication using bolted compression lugs for internal wiring.
   3. Integral disconnect switch.
   4. Redundant suppression circuits.
   5. Redundant replaceable modules.
   6. Arrangement with copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.
   7. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
   8. LED indicator lights for power and protection status.
   9. Audible alarm, with silencing switch, to indicate when protection has failed.
   10. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status. Coordinate with building power monitoring and control system.
   11. Surge-event operations counter.

B. Peak Single-Impulse Surge Current Rating: 300kA per phase.

C. Connection Means: Permanently wired.

D. Adjust to power standards in the Philippines - US standards protection modes and UL 1449 SVR for grounded wye circuits with voltages of 480Y/277, 3- phase, 4-wire circuits shall be
   1. Line to neutral.
   2. Line to ground.
   3. Neutral to ground 320V.

E. Accessories:
   1. Form-C contacts, one normally open and one normally closed, for remote monitoring of system operation. Contacts to reverse position on failure of any surge diversion module.
   2. Audible alarm activated on failure of any surge diversion module.
   3. Six-digit transient-counter set to total transient surges that deviate from the sine-wave envelope by more than 125 V.

F. The surge protection shall be rated for “Lightning Surges” in accordance with UL master label requirements for lightning protection systems.

2.03 ENCLOSURES

A. NEMA 1, with type matching the enclosure of panel or device being protected.

3.00 EXECUTION

3.01 INSTALLATION OF SURGE PROTECTION DEVICES

A. Install device at service entrance on load side, with ground lead bonded to service entrance ground.

B. Install device near the panelboard, less than 3 meters distance (10 ft.)

3.02 PLACING SYSTEM INTO SERVICE

A. Do not energize or connect service entrance equipment to their sources until surge protection device is installed and connected.

B. Do not close the circuit breaker until the surge protection device is installed and connected.

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust equipment installation, including connections, and to assist in field testing. Report results in writing.

1. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

3.04 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transient voltage suppression devices. Refer to Division 1 Section "Closeout Procedures" and/or “Demonstration and Training."

END OF SECTION 16289

SECTION 16410
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

1.00 GENERAL

1.01 SCOPE OF WORK

A. This Section includes the following individually mounted, enclosed switches and circuit breakers:
   1. Fusible switches.
   2. Nonfusible switches.
   3. Bolted-pressure contact switches.
   4. High-pressure, butt-type contact switches.
   5. Molded-case circuit breakers (MCCB).
   6. Molded-case switches.
   7. Enclosures.

B. This section applies to all MCCB's whether individually enclosed, group mounted, or furnished as part of other equipment.

C. MCCB's shall be factory mounted in respective enclosures or assemblies.

1.02 DEFINITIONS

A. GFCI: Ground-fault circuit interrupter.

B. HD: Heavy duty.

C. RMS: Root mean square.

D. SPDT: Single pole, double throw.

1.03. 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, and finishes.
   1. Enclosure types and details for types other than NEMA 250, Type 1.
   2. Current and voltage ratings.
   3. Short-circuit current rating.
   4. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that enclosed switches and circuit breakers, accessories, and components will withstand seismic forces defined in Division 16 Section "Electrical Supports and Seismic Restraints." 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."
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.

D. Field quality-control test reports including the following:
1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

E. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Sections "Closeout Procedures" and "Operation and Maintenance Data," include the following:
1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
2. Time-current curves, including selectable ranges for each type of circuit breaker.

F. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

G. Product data for each type of product specified.

1.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Third party listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

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. NEMA Publications AB 1: Molded Case Circuit Breakers (MCCB's).

E. UL Standard No. 489: Circuit Breakers.

F. Third Party Agency Compliance: Provide products which have been listed and/or labeled by a third party agency accredited by the NCBCC to label electrical and mechanical equipment as of August 1, 1991

1.05 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:

1. Ambient Temperature: Not less than minus 20 degrees Celsius (68 deg F) and not exceeding 37 degrees Celcius (98 deg F). Due to high humidity heat can be perceived to be as high as 39 degrees Celcius (102 deg F).
2. Altitude: Manila is at sea level. Project site is from 2-3 meters above seal level.

1.06 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.07 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Spares: For the following:
      a. Potential Transformer Fuses: Two.
      b. Control-Power Fuses: Three.
      c. Fuses and Fusible Devices for Fused Circuit Breakers: Two.
      d. Fuses for Fusible Switches: Six.
      e. Fuses for Fused Power Circuit Devices: Six.
   2. Spare Indicating Lights: Two of each type installed.

2.00 PRODUCTS

2.01 GENERAL

A. Ratings and special features shall be as scheduled.

B. Trips shall be thermal magnetic with inverse time delay and instantaneous time current characteristics.

C. Motor circuit protectors (MCP's) having magnetic only trips shall be provided where indicated.

D. MCCB's used outdoors shall have ambient compensating trips.

E. MCCB's used for switching lights shall be rated for switching duty and shall be so labeled.

F. MCCB's used for overcurrent protection for HVAC equipment shall be rated "HACR" type and shall be so labeled.

G. MCCB's shall be industrial grade (bolt on) as scheduled on the Drawings.

H. MCCB's to be installed in existing panelboards shall be of the same manufacturer as the panelboard.

I. Enclosures for individually enclosed MCCB's shall be NEMA 1 or NEMA 12 indoors and NEMA 3R or NEMA 4X outdoors unless indicated otherwise on the Drawings.

2.02 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.

B. Subject to compliance with requirements, provide MCCB's of one of the following:
   1. Cutler Hammer
   2. Square D
   3. Siemens

2.03 FUSIBLE AND NONFUSIBLE SWITCHES

A. Manufacturers:
   1. Eaton Corporation; Cutler-Hammer Products.
   2. Siemens Energy & Automation, Inc.
   3. Square D/Group Schneider.

B. Switches shall have handles whose positions are easily recognizable in the "on" and "off" positions.

C. Switches shall have nonteasible, positive, quick make-quick break mechanisms.

D. Fusible Switch, 1200 A and Smaller: NEMA KS 1, Type HD, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept two padlocks, and have defeatable interlocks that prevent door from opening when the operating handle is in the "on" position.

E. Nonfusible Switch, 1200 A and Smaller: NEMA KS 1, Type HD, lockable handle with capability to accept two padlocks, and have defeatable interlocks that prevent door from opening when the operating handle is in the "on" 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; and labeled for copper and aluminum neutral conductors.
   3. Auxiliary Contact Kit: Auxiliary set of contacts arranged to open before switch blades open.

2.04 FUSED POWER CIRCUIT DEVICES

A. Bolted-Pressure Contact Switch: UL 977; operating mechanism shall use a rotary-mechanical- bolting action to produce and maintain high-clamping pressure on the switch blade after it engages the stationary contacts.
   1. Manufacturers:

a. Eaton Corporation; Cutler-Hammer Products.
b. Siemens Energy & Automation, Inc.
c. Square D/Group Schneider.

B. High-Pressure, Butt-Type Contact Switch: UL 977; operating mechanism shall use butt-type contacts and a spring-charged mechanism to produce and maintain high-contact pressure when switch is closed.
1. Manufacturers:
a. Cutler-Hummer.
b. ASCO; American Switch Company.
c. Square D; Group Schneider.
2. Main Contact Interrupting Capability: Twelve times the switch current rating, minimum.
3. Operating Mechanism: Manual handle operation to close switch stores energy in mechanism for closing and opening.
a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
b. Mechanical Trip: Operation of mechanical lever or push button or another device causes switch to open.
4. Auxiliary Switches: Factory installed, SPDT, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
5. Service-Rated Switches: Labeled for use as service equipment.
6. Ground-Fault Relay: Comply with UL 1053. Self-powered type with mechanical ground- fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.
a. Configuration: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground fault indicator.
b. Internal Memory: Integrates the cumulative value of intermittent arcing ground- fault currents and uses the effect to initiate tripping.
c. No-Trip Relay Test: Operation of "no-trip" test control permits ground-fault simulation test without tripping switch.
d. Test Control: Simulates ground fault to test relay and switch (or relay only if "no- trip" mode is selected).
7. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

2.05 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

A. Manufacturers:
1. Eaton Corporation; Cutler-Hammer Products.
2. Siemens Energy & Automation, Inc.
3. Square D/Group Schneider.

B. Molded-Case Circuit Breaker: NEMA AB 1, 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-Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:
   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments.
   d. Ground-fault pickup level, time delay, and I2t response.
4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller and 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 and trip activation on fuse opening or on opening of fuse compartment door.
6. GFCI Circuit Breakers: Single- and two-pole configurations with 5-mA trip sensitivity.

C. Molded-Case Circuit-Breaker Features and Accessories:
1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical style with compression lug kits suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
4. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
5. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 16 Section "Electrical Power Monitoring and Control."
6. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
7. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
8. Auxiliary Switch: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
9. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
10. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

D. Molded-Case Switches: Molded-case circuit breaker with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

E. Molded-Case Switch Accessories:
1. Lugs: Mechanical style with compression lug kits suitable for number, size, trip ratings, and material of conductors.
2. Application Listing: Type HACR for heating, air-conditioning, and refrigerating equipment.
3. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage. Provide "dummy" trip unit where required for proper operation.

4. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay. Provide "dummy" trip unit where required for proper operation.
5. Auxiliary Switch: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit- breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
6. Key Interlock Kit: Externally mounted to prohibit operation; key shall be removable only when switch is in off position.

2.06 ENCLOSURES

A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.
1. Outdoor Locations: NEMA 250, Type 3R.
2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
4. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

3.00 EXECUTION

3.01 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance.

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

3.02 CONCRETE BASES

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

B. Concrete base is specified in Division 16 Section "Electrical Supports and Seismic Restraints," and concrete materials and installation requirements are specified in Division 3.

3.03 INSTALLATION

A. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.

B. Mount individual wall-mounting switches and circuit breakers with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to concrete base.

C. Comply with mounting and anchoring requirements specified in Division 16 Section "Electrical Supports and Seismic Restraints."

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install MCCB's as indicated on the Drawings.

F. Ganged use of single pole breakers for multi pole applications is not acceptable.

3.04 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Electrical Identification."

B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate as specified in Division 16 Section "Electrical Identification."

3.05 FIELD QUALITY CONTROL

A. Provide for factory authorized technicians to perform testing according to the manufacturer's recommendations. Preparations for testing shall include, but are not limited to the following:
   1. Inspect mechanical and electrical connections.
   2. Verify switch and relay type and labeling verification.
   3. Verify rating of installed fuses.
   4. Inspect proper installation of type, size, quantity, and arrangement of mounting or anchorage devices complying with manufacturer's certification.

B. Perform the following field tests and inspections and prepare test reports:
   1. For services 1000 amperes and larger, the following tests should be performed on the service circuit breakers and the distribution circuit breakers. Testing shall be performed by a qualified factory technician at the job site. All readings shall be tabulated:
      a. Phase tripping tolerance (within 20% of U/L requirements).
      b. Trip time (per phase) in seconds.
      c. Instantaneous trip (amps) per phase.
      d. Insulation resistance (in megaohms) at 100 volts (phase to phase, and line to load).
   2. The ground fault protection on the new circuit breakers shall be performance tested in the field and properly calibrated and set in accordance with the coordination study.
   3. All tests specified shall be completely documented indicating time of day, date, temperature and all pertinent test information.
   4. Test mounting and anchorage devices according to requirements in Division 16 Section "Electrical Supports and Seismic Restraints".
   5. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   6. Infrared Scanning:
      a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Open or remove doors or panels so connections are accessible to portable scanner.
      b. Follow-Up Infrared Scanning: Perform an additional follow-up infrared scan of each unit 11 months after date of Substantial Completion.
      c. Instruments, Equipment and Reports:
         1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

2) Prepare a certified report that identifies enclosed switches and circuit breakers included and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

7. All required documentation of readings indicated above shall be submitted to the engineer prior to, and as one of the prerequisites for, final acceptance of the project.

3.06 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.07 CLEANING

A. On completion of installation, vacuum dirt and debris from interiors; do not use compressed air to assist in cleaning.

B. Inspect exposed surfaces and repair damaged finishes.

END OF SECTION 16410

SECTION 16415
TRANSFER SWITCHES

1.00 GENERAL

1.01 SCOPE OF WORK

A. This Section includes transfer switches rated 600 V and less, including the following:

1. Automatic transfer switches.
2. Nonautomatic transfer switches.
3. Remote annunciation systems.
4. Remote annunciation and control systems.

1.02 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.

C. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 16 Section "Electrical Supports and Seismic Restraints." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Qualification Data: For manufacturer and testing agency.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "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.

1.03 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.

C. Source Limitations: Obtain automatic transfer switches through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

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.

1.04 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or adjacent property Owners unless permitted under the following conditions and then only after arranging to provide temporary electrical service:

1. Notify Architect/ Engineer of record, Construction Manager, and Owner's representative no fewer than two days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Owner representative's written permission.

1.05 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

2.00 PRODUCTS

2.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. Transfer switches using externally mounted service entrance rated molded-case circuit breakers in separate enclosures:
   a. ASCO.
   b. Eaton Electrical Inc.; Cutler-Hammer.
   c. GE Zenith Controls.

d. Russelectric.
e. Square D.

2.02 SYSTEM OPERATION

A. Utility (Normal) Power

1. When the utility power available, the transfer switch is on the normal power source mode.

B. Generator (Alternate) Power

1. Upon loss of normal power, the transfer switch sends a signal to diesel generator to start the engine.
2. When the alternate power becomes available, the loads are transferred to the alternate power.
3. When the load rises and exceeds 90% of the generator capacity, the transfer switch will send a (load-shed) signal to open circuit breaker(s). This signal is maintained until the load decreases to below 60% of the generator capacity or is transferred back to the normal power (with 30 second delay).

2.03 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.

C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric- motor-operated mechanism, mechanically and electrically interlocked in both directions.

F. Switch shall be Closed-Transition and transfer within 5 electrical degrees achieved passively without control of the engine generator set. Switch shall have built in failure to synchronize and extended parallel time protection to prevent abnormal operation.

G. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Switch Action: Double throw; mechanically held in both directions.

2. 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.

H. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.

I. Neutral Terminal: Solid and fully rated, unless otherwise indicated.

J. Not used.

K. 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.

L. 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 Division 16 Section "Electrical Identification."
   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.

M. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.04 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 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. Load Shedding: Relay and timer to send signal to open circuit breaker(s) when the load rises and exceeds 90% of generator capacity; and, to close circuit breaker(s) when the load decreases below 60% of generator capacity or is transferred back to normal power (with 30 sec. delay).

11. 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.

12. 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.

2.05 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.

3.00 EXECUTION

3.01 INSTALLATION

A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 16 Section "Electrical Supports and Seismic Restraints."

B. Floor-Mounting Switch: Anchor to floor by bolting.
   1. Concrete Bases: 4 inches high, reinforced, with chamfered edges. Extend base no more than 4 inches in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 16 Section "Electrical Supports and Seismic Restraints."

C. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.

D. Identify components according to Division 16 Section "Electrical Identification."

E. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.02 CONNECTIONS

A. Ground equipment according to Division 16 Section "Grounding and Bonding."

B. Connect wiring according to Division 16 Section "Conductors and Cables."

3.03 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified independent testing and inspecting agency to perform tests and inspections and prepare test reports.

B. Testing Agency's Tests and Inspections:
   1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
   2. Provide for factory authorized technicians to perform testing according to the manufacturer’s recommendations.
   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. 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.

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.

C. Coordinate tests with tests of generator and run them concurrently.

D. 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.

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

F. 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.

3.04 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 Division 1 Section "Demonstration and Training."

B. Coordinate this training with that for generator equipment.

END OF SECTION 16415

SECTION 16420
ELECTRICAL DISTRIBUTION SYSTEM

1.00 GENERAL REQUIREMENTS

1.01 SCOPE OF WORK

Furnish materials and equipment and perform labor required to complete the following:

- Power distribution system
- Lighting system
- Communication Systems (Telephone, Intercom, Public Address & Sound)
- WiFi Systems
- CCTV, CATV & MATV System
- Lightning Protection System

Refer to drawings for extent and magnitude of work.

2.00 PRODUCTS

Refer to Section 01020 Summary of Materials and Finishes

3.00 EXECUTION

3.01 POWER SYSTEM

A. Unless otherwise indicated on drawings, do all wiring for power, connections of motors and line switches, motor starters, speed regulators, circuit breakers, compensators or any other appliance or electrical component that may need motors and specific power requirement. Present a representative when the motors are first started by the supplier for testing.

B. Wire control may be 3.5 mm^2, 5.5 mm^2 and 8.0 mm^2 Type “THWN” and color-coded for easy identification. Use PHELPS DODGE, or approved equal.

3.02 LIGHTING SYSTEM

A. Install all wiring in rigid conduit and, in general, conceal them in the structure, except connections to luminous recessed fluorescent troughs, which shall be in flexible steel conduit or ACT cable.

B. Balance lighting conduits at the panels on the 1-phase, 3-wire systems.

3.03 COMMUNICATION SYSTEM

Telephone and Intercom Systems:

A. Furnish and install conduits, cables, telephone & intercom cabinets, terminal blocks, pull boxes, telephone & intercom outlets, and telephone/intercom lines as per plans, and other outlets and/or lines the Architect may consider necessary. Provide telephone backing.

B. Furnish and install conduits, cables for public address and sound system.

C. Install all wiring in rigid conduit.

3.04 WIFI SYSTEM

Wifi System:

A. Furnish and install conduits, cables, hubs and routers for each floor to service all studio units. Connect to UP Dilnet when possible.
B. Install all wiring in rigid conduit.

3.05 AUDIO-VISUAL SYSTEM: CCTV, CATV AND MATV

CCTV, CATV AND MATV:

A. Furnish and install conduits, cables and CCTV units in three locations: ground floor front entrance, left entrance and right entrance.
B. Furnish and install conduits, cables for CATV and MATV in all studio units.
C. Install all wiring in rigid conduit.

3.06 FIRE ALARM AND SIGNALLING BELL SYSTEM

A. Install all wiring in rigid conduit and, in general, conceal them in the structure.
B. Install components at terminals as the general location indicated in the plans, and in conformity with the respective specifications for the systems. Confirm the exact placement of components with the Architect prior to implementation and installation.

3.07 LIGHTNING ARRESTER

A. Use bare copper wire, 22mm^2 for line inside, and grounding rod 20 mm diameter x 3.00 meters solid copper embedded in the ground. Install where indicated by Electrical Engineer.
B. Fix the cable securely to the base of the finial and to the solid rod at its base. Drop the cable at the center of the spire avoiding contact with any of the steel reinforcement.

END OF SECTION 16420

SECTION 16441
SWITCHBOARDS

1.00 GENERAL

1.01 SCOPE OF WORK

A. This Section includes service and distribution switchboards rated 600 V and less.

1.02 DEFINITIONS

A. EMI: Electromagnetic interference.
B. GFCI: Ground-fault circuit interrupter.
C. RFI: Radio-frequency interference.
D. RMS: Root mean square.
E. SPDT: Single pole, double throw.

1.03 SUBMITTALS

A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Enclosure types and details for types other than NEMA 250, Type 1.
b. Bus configuration, current, and voltage ratings.
c. Short-circuit current rating of switchboards and overcurrent protective devices.
d. Descriptive documentation of optional barriers specified for electrical insulation and isolation.
e. Utility company's metering provisions with indication of approval by utility company.
f. Mimic-bus diagram.
g. UL listing for series rating of installed devices.
h. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Wiring Diagrams: Power, signal, and control wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 16 Section "Electrical Supports and Seismic Restraints." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Sections "Closeout Procedures" and "Operation and Maintenance Data," include the following:
1. Routine maintenance requirements for switchboards and all installed components.
2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
3. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.04 QUALITY ASSURANCE

A. Source Limitations: Obtain switchboards through one source from a single manufacturer.
B. 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.
C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
D. Comply with NEMA PB 2, "Deadfront Distribution Switchboards."
E. Comply with NFPA 70.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver in sections or lengths that can be moved past obstructions in delivery path.
B. Store indoors in clean dry space with uniform temperature to prevent condensation. Protect from exposure to dirt, fumes, water, corrosive substances, and physical damage.
C. Handle switchboards according to NEMA PB 2.1 and NECA 400.

1.06 PROJECT CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.
B. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
1. Ambient Temperature: Not exceeding 45 deg Celsius (113 deg F).
2. Altitude: Not exceeding 100 meters (3300 feet).
C. Service Conditions: NEMA PB 2, usual service conditions, as follows:
1. Ambient temperatures within limits specified.
2. Altitude not exceeding 100 meters (3300 feet).

1.07 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.08 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Potential Transformer Fuses: Equal to 10 percent of amount installed for each size and type, but no fewer than 2 of each size and type.
   2. Control-Power Fuses: Equal to 10 percent of amount installed for each size and type, but no fewer than 2 of each size and type.
   3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of amount installed for each size and type, but no fewer than 3 of each size and type.
   4. Indicating Lights: Equal to 10 percent of amount installed for each size and type, but no fewer than 1 of each size and type.

2.00 PRODUCTS

2.01 SYSTEM OPERATION

A. Normal Power (Utility)
   1. Main breakers are closed and tie-in breaker is open.
   2. Draw-out breakers are closed. Upon loss of power, the draw-out breakers will open.

B. Alternate Power (two standby generators)
   1. Main breakers are closed and tie-in breaker is open.
   2. The draw-out breaker(s) will close 30 second after power is restored and the load is less than 60% of generator capacity.
   3. The draw-out breaker(s) will be opened when the load rises and exceeds 90% of generator capacity.
   4. The draw-out breaker(s) will be closed when the load decreases below 60% of generator capacity (30 second delay).

C. Alternate Power (Only one standby generator)
   1. One (1) main and tie-in breakers are closed. The other main breaker is open.
   2. The draw-out breaker(s) stay opened (electrically interlocked with tie-breaker).

2.02 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.

2.03 MANUFACTURED UNITS

A. Manufacturers:
   1. Eaton Corporation; Cutler-Hammer Products.
   2. Siemens Energy & Automation, Inc.
   3. Square D.

B. Front-Connected, Front-Accessible Switchboard: Panel-mounted main device, panel-mounted branches, and sections rear aligned.

C. Nominal System Voltage: 480Y/277 V.

D. Main-Bus Continuous: Fully rated for entire length of switchboard with rating shown on plans. E. Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Division 16 Section "Electrical Supports and Seismic Restraints."

F. Enclosure: Steel, NEMA 250, Type 1.

G. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

H. Barriers: Between adjacent switchboard sections.

I. Insulation and isolation for main and vertical buses of feeder sections.

J. Metering Compartment: Fabricated compartment and section to include phase ammeters, voltmeters and wattmeters for main busses.

K. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

L. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

M. Pull Box on Top of Switchboard:

1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
2. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
3. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
4. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

N. Buses and Connections: Three phase, four wire, unless otherwise indicated.

1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity with silver plate.
   a. Use copper for feeder circuit-breaker line connections.
2. Ground Bus: 1/4-by-2-inch minimum-size, hard-drawn copper of 98 percent conductivity, equipped with pressure connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
3. Contact Surfaces of Buses: Silver plated.
4. Main Phase Buses, Neutral Buses, and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
5. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
6. Neutral Buses: 100 percent of the ampacity of phase buses, unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables. Bus extensions for busway feeder neutral bus are braced.

O. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

P. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating: 105 deg C.

2.04 TRANSIENT VOLTAGE SUPPRESSION DEVICES

A. Refer to Section 16289 – Transient Voltage Suppression.

2.05 OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker: NEMA AB 3, 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-unit circuit breakers shall have RMS sensing, field-replaceable rating plug, and the following field-adjustable settings:
   a. Instantaneous trip.
4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and two-pole configurations with [5] [30]-mA trip sensitivity.

B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.

1. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
3. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
4. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system, specified in Division 16 Section "Electrical Power Monitoring and Control."
5. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
7. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
8. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
9. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking

ground-fault protection function.

C. Draw-out Circuit Breakers: Comply with IEEE C37.13.

1. Ratings: As indicated for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchboard.
2. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism to open and close the breaker with the following features:
   a. Normal Speed: Independent of both control and operator.
   b. Slow Speed: Optional with operator for inspection and adjustment.
   c. Stored-Energy Mechanism: Electrically charged, with optional manual charging.
   d. Operation counter.
3. 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:
   a. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
   b. Temperature Compensation: Ensures accuracy and calibration stability from minus 5 to plus 40 deg C.
   c. Field-adjustable, time-current characteristics.
   d. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.
   e. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
   f. Pickup Points: Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I2t operation.
   g. Pickup Points: Five minimum, for instantaneous-trip functions.
   h. 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 Four-wire circuit system.
   i. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.
4. 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.
5. Draw-out 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:
   a. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed.
   b. 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:

1) Test Position: Primary disconnect devices disengaged, and secondary disconnect devices and ground contact engaged.
2) Disconnected Position: Primary and secondary devices and ground contact disengaged.

6. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position; arranged to permit inspection of contacts without removing circuit breaker from switchboard.
7. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.
8. Operating Handle: One for each circuit breaker capable of manual operation.
9. Electric Close and Open Buttons: One for each electrically operated circuit breaker.
10. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.
11. Key Interlocks: Arranged so keys are attached at devices indicated. Mountings and hardware are included where future installation of key-interlock devices is indicated.
12. Undervoltage Trip Devices: Adjustable time-delay and pickup voltage.

D. Indicating Lights: To indicate draw-out circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.

E. Fuses are specified in Division 16 Section "Fuses."

2.06 INSTRUMENTATION

A. Instrument Transformers: NEMA EI 21.1, IEEE C57.13, and the following:

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 shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments.
3. Control-Power Transformers: Dry type, sized to power meters, control device, indicating lights and stored-energy operating mechanism to open and close the breaker, mounted in separate compartments for units larger than 3 kVA.
4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondaries to ground overcurrent relays to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four- wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
   a. Phase Currents, Each Phase: Plus or minus 1 percent.
   b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
   c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
   d. Megawatts: Plus or minus 2 percent.
   e. Megavars: Plus or minus 2 percent.
   f. Power Factor: Plus or minus 2 percent.
   g. Frequency: Plus or minus 0.5 percent.
   h. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from 5 to 60 minutes.

i. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent. Accumulated values unaffected by power outages up to 72 hours.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

2.07 CONTROL POWER

A. Control Circuits: 120 V, supplied through secondary disconnecting devices from control-power transformer.

B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

C. 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.

2.08 ACCESSORY COMPONENTS AND FEATURES

A. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Furnish portable test set to test functions of solid-state trip devices without removal from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

C. Furnish one portable, floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.

D. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

E. Fungus Proofing: Permanent fungicidal treatment for switchboard interior, including instruments and instrument transformers.

2.09 IDENTIFICATION

A. Mimic Bus: Continuously integrated mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic- bus diagram. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.

B. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.

C. Upon completion of installation, and prior to final inspection, the contractor shall reduce in size the "as-built" single line diagram (riser), frame same under glass, and mount in a conspicuous place adjacent to the switchboard.

3.00 EXECUTION

3.01 PROTECTION

A. Apply temporary site conditions for installation according to manufacturer's written instructions.

3.02 EXAMINATION

A. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance.

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

3.03 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1 and NECA 40.

B. Install and anchor switchboards level on concrete bases, 4-inch (100-mm) nominal thickness. Concrete base is specified in Division 16 Section "Electrical Supports and Seismic Restraints," and concrete materials and installation requirements are specified in Division 3.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
2. For switchboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to switchboards.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. 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.

E. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.

1. Set field-adjustable switches and circuit-breaker trip ranges.

F. Install spare-fuse cabinet.

3.04 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Electrical Identification."

B. Switchboard Nameplates: Label each switchboard compartment with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.05 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Perform the field tests and inspections and prepare test reports as required by Section 16410 paragraph 3.5 and 3.6.

3.06 CLEANING

A. On completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.07 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. Refer to Division 1 Section "Demonstration and Training."

END OF SECTION 16441

SECTION 16442
PANELBOARDS

1.00 GENERAL

1.01 DESCRIPTION OF WORK

A. This Section includes the following:

1. Extent of panelboard, load-center and enclosure work, including cabinets and cutout boxes is indicated by the Drawings and Schedules.
2. Types of panelboard and enclosures required for the project include the following:
3. Power-distribution panelboards.
4. Lighting and appliance panelboards.
5. Refer to other Division 16 sections for wires/cables, electrical boxes and fittings, and raceway work required in conjunction with installation of panelboards and enclosures.

1.02 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. RFI: Radio-frequency interference.

D. RMS: Root mean square.

E. SPDT: Single pole, double throw.

1.03 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product Data: For each type of panelboard, overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

C. Shop Drawings: For each panelboard and related equipment.

1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:
   a. Enclosure types and details for types other than NEMA 250, Type 1.
   b. Bus configuration, current, and voltage ratings.
   c. Short-circuit current rating of panelboards and overcurrent protective devices.
   d. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
2. Wiring Diagrams: Power, signal, and control wiring.

D. Panelboard Schedules: For installation in panelboards. Panel schedule directory cards will be typed after load balancing and mounted in plastic sleeve on inside of door.

E. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Sections "Closeout Procedures" and "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.

F. Product Data: Submit manufacturer's data on panelboards and enclosures.

G. Shop Drawings: Submit layout drawings of panelboards showing accurately scaled basic equipment sections, auxiliary compartments and combination sections. In addition, show spacial relationships of units to associated equipment.

H. Wiring Diagrams: Submit wiring diagrams for panelboards showing connections to electrical power feeders and distribution branches.

I. Maintenance data for materials and products for inclusion in Operating and Maintenance Manual specified in Division 1 and Section 16010 - Basic Electrical Requirements.

1.04 QUALITY ASSURANCE

A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of panelboards and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

F. Manufacturers: Firms regularly engaged in manufacture of panelboards and enclosures, of types, sizes, and ratings required, whose products are UL listed and/or labeled for the purpose intended.

G. Electrical Code Compliance: Comply with applicable State code requirements of the authority having jurisdiction and NEC Article 384 as applicable to installation and construction of electrical panelboards and enclosures.

H. UL Compliance: Comply with applicable requirements of Std No. 67, "Electric Panelboards", and Stds No.'s 50, 869, 486A, 486B, and 1053 pertaining to panelboards, accessories and enclosures. Provide units which are UL listed and/or labeled.

I. Third Party Agency Compliance: Provide products which have been listed and/or labeled by a third party agency accredited by the NCBCC to label electrical and mechanical equipment as of August 1, 1991.

J. Special-Use Markings: Provide panelboards, constructed for special-use, with appropriate UL marks which indicates that they are suitable for special type of use/application including service entrance equipment.

K. NEMA Compliance: Comply with NEMA Stds Pub/No. 250 "Enclosures for Electrical Equipment (1000 Volts Maximum)", Pub/No. PB 1, "Panelboards", and Pub/No. PB 1.1, "Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 volts or Less"

1.05 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
   1. Ambient Temperature: Not exceeding 104 deg F.
   2. Altitude: Not exceeding 100 meters (3300 feet).

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 100 meters (3300 feet).

1.06 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.07 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Keys: Six spares for each type of panelboard cabinet lock.

2.00 PRODUCTS

2.01 MANUFACTURERS

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

1. Panelboards, Overcurrent Protective Devices, Controllers, Contactors, and Accessories:
   a. Eaton Corporation; Cutler-Hammer Products.
   b. Siemens Energy & Automation, Inc.
   c. Square D.

2.02 MANUFACTURED UNITS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 16 Section "Electrical Supports and Seismic Restraints

B. Enclosures: Flush- and surface-mounted cabinets. NEMA PB 1, Type 1.

1. Rated for environmental conditions at installed location.
   a. Outdoor Locations: NEMA 250, Type 3R.
   b. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
   c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
   d. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.
2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
3. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
4. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
5. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.
6. Directory Card: With transparent protective cover, mounted in metal frame, inside panelboard door.

C. Phase and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Equipment Ground Bus: 100 percent for feeder and branch-circuit equipment ground conductors; bonded to box.
3. Isolated Equipment Ground Bus: Adequate for branch-circuit equipment ground conductors; insulated from box.
4. Neutral Bus: 100 percent of phase bus.

D. Conductor Connectors: Suitable for use with conductor material.

1. Main and Neutral Lugs: Mechanical type.
2. Ground Lugs and Bus Configured Terminators: Compression type.
3. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

E. Service Equipment Label: Third party labeled for use as service equipment for panelboards with main service disconnect switches.

F. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.

G. All bus bars shall be copper.

H. Feed-through panels are not permitted.

I. Series rating is not permitted.

2.03 PANELBOARD SHORT-CIRCUIT RATING

A. Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.04 DISTRIBUTION PANELBOARDS

A. Doors: Secured with vault-type latch with tumbler lock; keyed alike. Omit for fused-switch panelboards.

B. Main Overcurrent Protective Devices: Circuit breaker.

C. Branch Overcurrent Protective Devices:

D. General: Except as otherwise indicated, provide panelboards, bolt-on breakers, integral common trip, enclosures and ancillary components, of types, sizes, and ratings indicated, which comply with manufacturer's standard materials; design and construction in accordance with published product information; equip with proper number of unit panelboard devices as required for complete installation. Where types, sizes, or ratings are not indicated, comply with NEC, UL and established industry standards for those applications indicated.

E. Power Distribution Panelboards: Provide factory assembled, dead front safety constructed, power distribution panelboards circuit breaker type, in sizes and ratings indicated, with panelboard switching and protective devices in quantities, ratings, types, characteristics and with arrangement indicated; with anti-turn solderless pressure type main lug connections approved for use with copper conductors.

F. Metering: Where shown on drawings, provide metering compartments for CT's, PT's and instrument transfer switches, and connect meters for sequence metering. Mount meters recessed in front doors and install meter wiring and lacing with sufficient flexibility at hinged edge of meter front mounting plates to prevent damage.

G. Construct panelboards with rectangular shaped bus bars of solid copper, with conductivity not less than 98%, which are securely mounted and braced, and with solderless lugs bolted to main bus bars, and with full sized neutral bus and bare uninsulated ground bus suitable for bolting to enclosures, suitable for service with 480Y/277 volts, 3 phase, 4 wire system.

H. Provide suitable lugs on neutral and ground busses for outgoing feeders requiring neutral and ground connections. Provide two ground busses (normal and isolated) for panels where indicated on the Drawings. Isolated ground bars shall be insulated and isolated from enclosure.

I. Provide molded case main and branch circuit bolt-on breaker types for each circuit, with toggle handles that indicate when tripped.

J. Where multiple pole breakers are indicated, provide with integral common trip so overload on one pole will trip all poles simultaneously.

K. Minimum short circuit rating for branch circuit breakers shall be as noted on the Drawings. Series ratings will not be acceptable.

L. Select enclosures as noted on the Drawings fabricated by the same manufacturer as the panelboards, which mate and match properly with the panelboards.

2.05 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

B. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

C. Lighting and Appliance Panelboards: Provide factory assembled, dead front safety constructed, lighting and appliance panelboards circuit breaker type, in sizes and ratings indicated, with panelboard switching and protective devices in quantities, ratings, types, characteristics and with arrangement indicated; with anti-turn solderless pressure type main lug connections approved for use with copper conductors.

1. Branch circuit breakers for lighting circuits shall be Type "SWD"; for air conditioning and appliance circuits, Type "HACR".
2. Panelboard Enclosures: Provide galvanized sheet steel cabinet type enclosures, in sizes and NEMA types as indicated, code-gage, minimum 16-gage thickness. Construct with no knockouts and code sized wiring gutters.
3. Provide fronts with adjustable trim clamps, and doors with flush locks and keys, all panelboard enclosures keyed alike, with concealed piano door hinges and door swings as indicated.
4. Equip with interior circuit-directory frame, and card with clear plastic covering.
5. Provide baked gray enamel finish over a rust inhibitor coating.
6. Design enclosures for recessed or surface mounting, as indicated on drawings.
7. Provide enclosures which are fabricated by same manufacturer as panelboards, which mate properly with panelboards to be enclosed.
8. Molded Case Circuit Breakers: Provide factory assembled, molded case circuit breakers of frame sizes, characteristics, and ratings including RMS symmetrical interrupting ratings indicated.
9. Select breakers with permanent thermal and instantaneous magnetic trip, and with fault current limiting protection, ampere ratings as indicated.
10. Construct with overcenter, trip free, toggle type operating mechanisms with quick-make, quick-break action and positive handle trip indication.
11. Construct breakers for mounting and operating in any physical position, and operating in an ambient temperature of 40EC.
12. Provide breakers with mechanical screw type removable connector lugs, AL/CU rated.
13. Panelboard Accessories: Provide panelboard accessories and devices including, but not necessarily limited to, cartridge and plug time-delay type fuses, circuit-breakers, ground- fault protection units, etc., as recommended by panelboard manufacturer for ratings and applications indicated.
14. Short Circuit Rating: Unless otherwise indicated, panelboards and all devices will have a minimum short circuit withstand rating as indicated on drawing. Series rated panelboards are not acceptable.

2.06 OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker: 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-unit circuit breakers shall have RMS sensing; field-replaceable rating plug; and with the following field-adjustable settings:
   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments.
   d. Ground-fault pickup level, time delay, and I2t response.
4. GFCI Circuit Breakers: Single- and two-pole configurations with 5-mA trip sensitivity.

B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.

1. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
3. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
4. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 16 Section "Electrical Power Monitoring and Control."
5. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
7. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
8. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
9. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
10. Multipole units enclosed in a single housing or factory-assembled to operate as a single unit.

C. Fuses are specified in Division 16 Section "Fuses."

2.07 ACCESSORY COMPONENTS AND FEATURES

A. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Furnish portable test set to test functions of solid-state trip devices without removal from panelboard.

C. Fungus Proofing: Permanent fungicidal treatment for panelboard interior, including overcurrent protective devices and other components.

3.00 EXECUTION

3.01 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Comply with mounting and anchoring requirements specified in Division 16 Section "Electrical Supports and Seismic Restraints."

C. Mount top of trim 74 inches above finished floor, unless otherwise indicated.

D. Mount plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.

E. Install overcurrent protective devices and controllers.

1. Set field-adjustable switches and circuit-breaker trip ranges.

F. Install filler plates in unused spaces.

G. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

H. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

I. General: Install panelboards and enclosures as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC standards and NECA's "Standard of Installation," and in compliance with recognized industry practices to ensure that products fulfill requirements.

J. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Stds 486A and B.

K. Fasten enclosures firmly to walls and structural surfaces, ensuring that they are permanently and mechanically anchored.

L. Provide properly wired electrical connections for panelboards within enclosures.

M. Fill out panelboard's circuit directory card with typewriter upon completion of installation work.

N. All neutral and ground wires shall have taped on numbers at panels indicating circuits served.

3.02 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Electrical Identification."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.03 CONNECTIONS

A. Ground equipment according to Division 16 Section "Grounding and Bonding."

B. Connect wiring according to Division 16 Section "Conductors and Cables."

3.04 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Perform the following field tests and inspections and prepare test reports:

1. Provide for factory authorized technicians to perform testing according to the manufacturer's recommendations.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.

1. Measure as directed during period of normal system loading.
2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

D. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scanning of each panelboard. Remove panel fronts so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 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 panelboards checked and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

E. Prior to energization of panelboards, check with ground resistance tester phase-to-phase and phase-to-ground insulation resistance levels to ensure requirements are fulfilled.

F. Prior to energization of electrical circuitry, check all accessible connections to manufacturer's tightening torque specifications.

G. Flush Mounted Panels: Provide one spare 3/4" empty conduit for every 3 spare breakers and/or spaces to above accessible ceiling.

H. Prior to energization, check panelboards for electrical continuity of circuits, and for short-circuits

I. Grounding:

1. Provide equipment grounding connections for panelboards as indicated.
2. Tighten connections to comply with tightening torques specified in UL Stds 486A to assure permanent and effective grounds.
3. Upon completion of installation work, properly ground panelboards and demonstrate compliance with requirements of Section 16060 - Grounding.

J. Adjusting and Cleaning:

1. Adjust operating mechanisms for free mechanical movement.
2. Touch-up scratched or marred surfaces to match original finishes.

K. Demonstration:

1. Subsequent to wire and cable hookups, energize panelboards and demonstrate functioning in accordance with requirements.
2. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

3.05 CLEANING

A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.06 TESTING

A. Test panelboards in accordance with Section 16050 Basic Electrical Materials and Methods.

3.07 EXAMINATION

A. Examine areas and conditions under which panelboards and enclosures are to be installed, and notify Engineer in writing of conditions detrimental to proper completion of work.

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

END OF SECTION 16442

SECTION 16450
ENCLOSED BUS ASSEMBLIES

1.00 GENERAL

1.01 SCOPE OF WORK

A. This Section includes the following:

1. Feeder-bus assemblies.
2. Plug-in bus assemblies.
3. Bus plug-in devices.

1.02 DEFINITIONS

A. TVSS: Transient voltage surge suppressor.

1.03 SUBMITTALS

A. Shop Drawings: For each type of bus assembly and plug-in device.

1. Show fabrication and installation details for enclosed bus assemblies. Include plans, elevations, and sections of components. Designate components and accessories, including clamps, brackets, hanger rods, connectors, straight lengths, and fittings.
2. Indicate required clearances, method of field assembly, and location and size of each field connection.
3. Detail connections to switchgear, switchboards, transformers, and panelboards.
4. Wiring Diagrams: Power wiring.
5. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer.
   a. Design Calculations: Calculate requirements for selecting seismic restraints.
   b. Detail fabrication, including anchorages and attachments to structure and to supported equipment.

B. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled bus-assembly layouts and relationships between components and adjacent structural, mechanical, and electrical elements. Show the following:

1. Vertical and horizontal enclosed bus-assembly runs, offsets, and transitions.
2. Clearances for access above and to the side of enclosed bus assemblies.
3. Vertical elevation of enclosed bus assemblies above the floor or bottom of structure.
4. Support locations, type of support, and weight on each support.

C. Location of adjacent construction elements including light fixtures, HVAC and plumbing equipment, fire sprinklers and piping, signal and control devices, and other equipment.

D. Product Certificates: For each type of enclosed bus assembly, signed by product manufacturer.

E. Manufacturer Seismic Qualification Certification: Submit certification that enclosed bus assemblies, plug-in devices, accessories, and components will withstand seismic forces defined in Division 16 Section "Electrical Supports and Seismic Restraints." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Qualification Data: For testing agency.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For enclosed bus assemblies to include in emergency, operation, and maintenance manuals.

1.04 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 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. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

C. Source Limitations: Obtain enclosed bus assemblies and plug-in devices through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with NEMA BU 1, "Busways."

F. Comply with NFPA 70.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle enclosed bus assemblies according to NEMA BU 1.1, "General Instructions for Proper Handling, Installation, Operation and Maintenance of Busway Rated 600 Volts or Less."

1.06 PROJECT CONDITIONS

A. Derate enclosed bus assemblies for continuous operation at indicated ampere ratings for ambient temperature not exceeding 122 deg F.

1.07 COORDINATION

A. Coordinate layout and installation of enclosed bus assemblies and suspension system with other construction that penetrates ceilings or floors or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

1.08 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Plug-in Units: 10 percent of amount installed for each size indicated, but no fewer than 2 unit(s).

2.00 PRODUCTS

2.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. Calvert Company (The).
2. Eaton Electrical Inc.; Cutler-Hammer Products.
3. Siemens Energy & Automation, Inc.

2.02 ENCLOSED BUS ASSEMBLIES

A. Feeder-Bus Assemblies: NEMA BU 1, low-impedance bus assemblies in nonventilated housing; single-bolt joints; ratings as indicated.

1. Seismic Fabrication Requirements: Fabricate mounting provisions and attachments for feeder-bus assemblies with reinforcement strong enough to withstand seismic forces defined in Division 16 Section "Electrical Supports and Seismic Restraints" when mounting provisions and attachments are anchored to building structure and seismic restraints.
2. Voltage: 120/208 V; 3 phase; 100 percent neutral capacity.
3. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
4. Bus Materials: Current-carrying copper conductors, fully insulated with Class 130C insulation except at joints; plated surface at joints.
5. Ground:
   a. 50 percent capacity internal bus bars of material matching bus material.
6. Enclosure: Steel with manufacturer's standard.
7. Fittings and Accessories: Manufacturer's standard.
8. Mounting: Arranged flat, edgewise, or vertically without derating.

B. Plug-in Bus Assemblies: NEMA BU 1, low-impedance bus assemblies in nonventilated housing; single-bolt joints; ratings as indicated.

1. Seismic Fabrication Requirements: Fabricate mounting provisions and attachments for switchboards with reinforcement strong enough to withstand

seismic forces defined in Division 16 Section "Electrical Supports and Seismic Restraints" when mounting provisions and attachments are anchored to building structure.

2.03 PLUG-IN DEVICES

A. Molded-Case Circuit Breakers: NEMA AB 1; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position.

B. TVSS: NEMA 250, Type 1 enclosure with NEMA KS 1, fusible, disconnect switch and external handle to isolate TVSS from busway. TVSS product and installation requirements are specified in Division 16 Section "Transient Voltage Suppression.".

1. Circuit-Breaker Disconnecting Means: NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

2. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 10 tripping characteristic. Overload relays shall have heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.

C. Accessories: Hookstick operator, adjustable to maximum extension of 14 feet.

3.00 EXECUTION

3.01 INSTALLATION

A. Support bus assemblies independent of supports for other elements such as equipment enclosures at connections to panelboards and switchboards, pipes, conduits, ceilings, and ducts.

1. Design each fastener and support to carry load indicated by seismic requirements and to comply with seismic-restraint details according to Division 16 Section "Electrical Supports

2. Design each fastener and support to carry 200 lb or 4 times the weight of bus assembly, whichever is greater.

3. Support bus assembly to prevent twisting from eccentric loading.

4. Support bus assembly with not less than 3/8-inch steel rods. Install side bracing to prevent swaying or movement of bus assembly. Modify supports after completion to eliminate strains and stresses on bus bars and housings.

5. Fasten supports securely to building structure according to Division 16 Section "Electrical Supports and Seismic Restraints."

B. Coordinate bus-assembly terminations to equipment enclosures to ensure proper phasing, connection, and closure.

C. Tighten bus-assembly joints with torque wrench or similar tool recommended by bus-assembly manufacturer. Tighten joints again after bus assemblies have been energized for 30 days.

D. Install bus-assembly, plug-in units. Support connecting conduit independent of plug-in unit.

3.02 CONNECTIONS

A. Ground equipment according to Division 16 Section "Grounding and Bonding."

B. Connect wiring according to Division 16 Section "Conductors and Cables."

3.03 FIELD QUALITY CONTROL

A. Testing Agency: will engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Provide for factory authorized technicians to perform testing according to the manufacturer's recommendations.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Remove and replace units that do not pass tests and inspections and retest as specified above.

D. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of bus assembly including joints and plug-in units.

1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
2. Perform 2 follow-up infrared scans of bus assembly, one at 4 months and the other at 11 months after Substantial Completion.
3. Prepare a certified report identifying bus assembly checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

E. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.04 ADJUSTING

A. Set field-adjustable, circuit-breaker trip ranges and overload relay trip settings as indicated.

3.05 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.06 PROTECTION

A. Provide final protection to ensure that moisture does not enter bus assembly.

END OF SECTION 16450

SECTION 16461
LOW VOLTAGE TRANSFORMERS

1.00 GENERAL

1.01 SCOPE OF WORK

A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:

1. Distribution transformers.

1.02 SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Qualification Data: For testing agency.

D. Source quality-control test reports.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.03 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, 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. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.

C. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

1.04 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.05 COORDINATION

A. Coordinate size and location of concrete bases with actual transformer provided.

2.00 PRODUCTS

2.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. Eaton Electrical Inc.; Cutler-Hammer Products.
2. Siemens Energy & Automation, Inc.
3. Square D; Schneider Electric.

2.02 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.

1. Internal Coil Connections:
2. Coil Material: Aluminum.

2.03 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Cores: One leg per phase.

C. Enclosure: Ventilated, NEMA 250, Type 2. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

D. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: Gray.

E. Taps for Transformers Smaller Than 3 kVA: None.

F. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

G. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

H. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 115deg C rise above 40 deg C ambient temperature.

I. Energy Efficiency for Transformers Rated 15 kVA and Larger:

1. Complying with NEMA TP 1, Class 1 efficiency levels.
2. Tested according to NEMA TP 1.

J. 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.

K. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
2. Include special terminal for grounding the shield.
3. Shield Effectiveness:
   a. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.
   b. Common-Mode Noise Attenuation: Minimum of minus 120 dBA at 0.5 to 1.5 kHz; minimum of minus 65 dBA at 1.5 to 100 kHz.
   c. Normal-Mode Noise Attenuation: Minimum of minus 52 dBA at 1.5 to 10 kHz.

L. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

2.04 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 Division 16 Section "Electrical Identification."

2.05 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.91.

B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

3.00 EXECUTION

3.01 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 Division 16 Section "Grounding and Bonding" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

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

3.02 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

B. Construct concrete housekeeping pad 4” high and anchor transformers according to manufacturer's written instructions.

3.03 CONNECTIONS

A. Ground equipment according to Division 16 Section "Grounding and Bonding."

B. Connect wiring according to Division 16 Section "Conductors and Cables."

3.04 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test as recommended by equipment manufacturer. Certify compliance with test parameters.

C. Remove and replace units that do not pass tests or inspections and retest as specified above.

D. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.

1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
2. Perform 2 follow-up infrared scans of transformers, one at 4 months and the other at 11 months after Substantial Completion.

3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

E. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.05 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.

C. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.06 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 16461

SECTION 16491
FUSES

1.00 GENERAL

1.01 SCOPE OF WORK

A. This Section includes the following:

1. Cartridge fuses rated 600 V and less for use in switches.
2. Spare-fuse cabinets.

B. Class LPS-RK(600V) dual element time delay.

C. Class LPN-RK(250V) dual element time delay.

1.02 SUBMITTALS

A. Product Data: Include the following for each fuse type indicated:

1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
2. Let-through current curves for fuses with current-limiting characteristics.
3. Time-current curves, coordination charts and tables, and related data.

B. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

1. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
2. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

C. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Division 1 Sections "Closeout Procedures" and "Operation and Maintenance Data," include the following:
   a. Let-through current curves for fuses with current-limiting characteristics.
   b. Time-current curves, coordination charts and tables, and related data.
   c. Ambient temperature adjustment information.

1.03 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses from a single manufacturer.

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

C. Comply with NEMA FU 1.

D. Comply with NFPA 70.

1.04 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.05 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size.

1.06 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Quantity equal to ten percent of each fuse type and size, but no fewer than three of each type and size.

2.00 PRODUCTS

2.01 GENERAL

A. Fuses shall be so selected as to provide a fully selective system.

B. The following criteria shall be followed for fuse selection:

CIRCUIT TYPE	FUSE TYPE
Service Entrance & Feeder Circuits over 600A	Class L, U/L listed, current limiting with 200K Amp interrupting rating.
Service Entrance & Feeder Circuits 600A and less	Class RK1 or J, U/L listed, current limiting with 200K Amp interrupting rating.
Motor, Motor Controller & Transformer Circuits	Class RK5, U/L listed, current limiting time delay, with 200K Amp interrupting rating.
Individual Equipment where fault current does not exceed 50KA	Class K5, U/L listed, with 50KA interrupting rating.

2.02 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following: Substitutions are allowed with but requests should be received 10 days prior to bid submission deadline.

1. Cooper Bussman, Inc.
2. Eagle Electric Mfg. Co., Inc.; Cooper Industries, Inc.
3. Ferraz Shawmut, Inc.
4. Tracor, Inc.; Littelfuse, Inc. Subsidiary.

2.03 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

2.04 SPARE-FUSE CABINET

A. Cabinet: Wall-mounted, 0.05 inch thick steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 38 mm (1-1/2 inch high) letters on exterior of door.
4. Fuse Pullers: For each size of fuse.

3.00 EXECUTION

3.01 EXAMINATION

A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

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

3.02 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s).

3.03 IDENTIFICATION

A. Install labels indicating fuse replacement information on inside door of each fused switch.

END OF SECTION 16491

SECTION 16511
INTERIOR LIGHTING

1.00 GENERAL

1.01 SCOPE OF WORK

A. This Section includes the following:
   1. Interior lighting fixtures, lamps, and ballasts.
   2. Emergency lighting units.
   3. Exit signs.
   4. Lighting fixture supports.
   5. Retrofit kits for fluorescent lighting fixtures.

B. Related Sections include the following:
   1. Division 13 Section "Lighting Controls" for manual or programmable control systems with low-voltage control wiring or data communication circuits.
   2. Division 16 Section "Wiring Devices" for manual wall-box dimmers for incandescent lamps.
   3. Division 16 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
   4. Division 16 Section "Stage Lighting" for theatrical lighting fixtures and their controls.
   5. Division 16 Section "Dimming Controls" for architectural dimming systems.

C. Extent, location, and details of interior lighting fixture work are indicated on the Drawings and in the Schedules.

D. Types of interior lighting fixtures in this section include the following:
   1. High intensity discharge (HID).
   2. Fluorescent.
   3. Incandescent.

1.02 DEFINITIONS

A. BF: Ballast factor.

B. CRI: Color-rendering index.

C. HID: High-intensity discharge.

D. LER: Luminaire efficacy rating.

E. Luminaire: Complete lighting fixture, including ballast housing if provided.

1.03 SUBMITTALS

A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
   1. Physical description of lighting fixture including dimensions.
   2. Emergency lighting units including battery and charger.
   3. Ballast.

4. Energy-efficiency data.
5. Photometric data, in IESNA format, based on laboratory tests of each lighting fixture type, outfitted with lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.
   a. Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program (NVLAP) for Energy Efficient Lighting Products.
6. Lighting fixtures.
7. Suspended ceiling components.
8. Structural members to which suspension systems for lighting fixtures will be attached.

B. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, signed by product manufacturer.

C. Qualification Data: For agencies providing photometric data for lighting fixtures.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency,

G. Manufacturer's Qualifications: Firms regularly engaged in manufacture of interior lighting fixtures of sizes, types and ratings required, whose products are UL listed and/or labeled.

H. Codes and Standards:

1. Electrical Code Compliance: Comply with applicable State code requirements of the installation, and construction of interior building lighting fixtures.
2. NEMA Compliance: Comply with applicable requirements of NEMA Stds Pub/No.'s LE 1 and LE 2 pertaining to lighting equipment.
3. Third Party Agency Compliance: Provide products which have been listed and/or labeled by a third party agency accredited by the NCBCC to label electrical and mechanical equipment as of August 1, 1991.
4. ANSI Labels: Provide fluorescent lamp ballasts, which comply with ANSI C82.11.

1.04 DELIVERY, STORAGE AND HANDLING

A. Deliver interior ligting fixtures in factory-fabricated containers or wrapping, which properly protect fixtures from damage.

B. Store interior lighting fixtures in original packaging. Store inside well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, laid flat and blocked off ground.

C. Handle interior lighting fixtures carefully to prevent damage, breaking, and scoring of finishes Do not install damaged units or components; replace with new.

D. Sequencing and Scheduling:

1. Coordinate with other work including wires/cables, electrical boxes and fittings, and raceways, to properly interface installation of interior lighting fixtures with other work.
2. Sequence interior lighting installation with other work to minimize possibility of damage and soiling during remainder of construction.

1.05 QUALITY ASSURANCE

A. Luminaire Photometric Data testing Laboratory Qualifications: Provided by manufacturers' laboratorires that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

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

C. Comply with NFPA 70.

1.06 WARRANTY

A. General Warranty

1. Emergency egress lighting and exit lighting units shall be warranted for three years. battery must have an additional two more years pro-rated warranty. Warranty shall start from the date of project final acceptance. Warranty shall be included in the close out documents.

B. Special Warranty for BALLASTS: Manufacturer's standard form in which ballast manufacturer agrees to repair or replace ballasts that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Electronic Ballasts: Five years from date of final acceptance of the work.

C. Special Warranty for T5 and T8 Fluorescent Lamps: Manufacturer's standard form, made out to Owner and signed by lamp manufacturer agreeing to replace lamps that fail in materials or workmanship, freight on board the nearest shipping point to Project site, within specified warranty period below.

1. Warranty Period for T5 and T8 Fluorescent Lamps: One year from date of final acceptance of the work.

1.07 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
2. Plastic Diffusers and Lenses: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
3. Battery and Charger Data: One for each type of emergency lighting unit.

4. Ballasts: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
5. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

2.00 PRODUCTS

2.01 MANUFCTURERS

A. Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to those listed below:

B. Interior Fixtures: Refer to Fixture Schedule on drawings.

1. Fluorescent Ballasts:
   a. Magnetek Model B232I-HP
   b. Motorola Model M2RNT81LL
   c. Goldstar Model GB2X32/HBF
   d. (or comparable 1, 3 or 4 lamp models of these ballasts)

2. High Intensity Discharge Ballasts:
   a. Advance Transformer Co.
   b. General Electric Co.
   c. Holophane Div.; Johns-Manville Corp.
   d. Jefferson Electric Co.

3. Lamps:
   a. General Electric
   b. Osram/Sylvania
   c. Philips

2.02 LIGHTING FIXTURES

A. General: Provide lighting fixtures, of sizes, types and ratings indicated; complete with, but not limited to, housings, energy efficient ballasts, starters, wiring, poles and standards.

B. Wiring: Provide electrical wiring within fixture suitable for connecting to branch circuit wiring.

C. Lamps:

1. All lamps of a particular type used on this Project shall be by one manufacturer.
2. All lamps of a particular type shall be from one production run.
3. Provide fluorescent lamps of energy saving types and wattages as indicated on the Drawings.
4. Provide HID lamps in types and wattages indicated on the Drawings.
5. Provide incandescent lamps in types and wattages as indicated on the Drawings.

D. Interior Lighting Fixture Types:

1. General: Fixtures must comply with minimum requirements as stated herein. Review Architectural Drawings and Specifications to verify ceiling types, modules, suspension systems appropriate to installation.
2. Refer to the Fixture Schedule on the Drawings for specific fixture requirements.

E. Examination:

1. Examine areas and conditions under which lighting fixtures are to be installed, and substrate for supporting lighting fixtures.
2. Notify Engineer in writing of conditions detrimental to proper completion of the work.

2.03 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

B. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.

C. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.

D. HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5B.

E. Metal Parts: Free of burrs and sharp corners and edges.

F. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.

G. 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.

H. 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.
4. Laminated Silver Metallized Film: 90 percent.

I. Plastic Diffusers, Covers, and Globes:

1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
   a. Lens Thickness: At least 0.125 inch minimum unless different thickness is indicated.
   b. UV stabilized.
2. Glass: Annealed crystal glass, unless otherwise indicated.

2.04 BALLASTS FOR LINEAR FLUORESCENT LAMPS

A. Where disconnecting means is required for the double-ended la disconnect shall be labeled and located next to the room's local s

B. Electronic Ballasts: Comply with ANSI C82.11; programmed start type, unless otherwise indicated, and designed for type and quantity of lamps served. Ballasts shall be designed f full light output unless dimmer or bi-level control is indicated.
   1. Total Harmonic Distortion Rating: Less than 10 percent.
   2. Transient Voltage Protection: IEEE 587, Category A or better and shall meet FCC Rules and Regulations, part 18.
   3. Operating Frequency: 20 kHz or higher.
   4. Lamp Current Crest Factor: 1.7 or less.
   5. BF: 0.85 or higher.
   6. Power Factor: 0.95 or higher.
   7. Ballast case temperature shall not exceed 25 deg C rise over 40 deg C ambient.
   8. Input current third harmonics shall not exceed ANSI recommendations (33 percent total harmonic distortion, 27.5 percent of the third triplets).
   9. Flicker shall be 15 percent or less with any lamp suitable for the ballast.

C. Electronic Programmed-Start Ballasts for T5 and T5HO Lamps: Comply with ANSI C82.11 the following:
   1. Lamp end-of-life detection and shutdown circuit for T5 diameter lamps.
   2. Automatic lamp starting after lamp replacement.
   3. Sound Rating: A.
   4. Total Harmonic Distortion Rating: Less than 20 percent.
   5. Transient Voltage Protection: IEEE 587, Category A or better.
   6. Operating Frequency: 20 kHz or higher.
   7. Lamp Current Crest Factor: 1.7 or less.
   8. BF: 0.95 or higher, unless otherwise indicated.
   9. Power Factor: 0.95 or higher.

D. Not Used.

E. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.
   1. Dimming Range: 100 to 5 percent of rated lamp lumens.
   2. Ballast Input Watts: Can be reduced to 20 percent of normal.
   3. Compatibility: Certified by manufacturer for use with specific dim lamp type indicated.

F. Ballasts for Bi-Level Controlled Lighting Fixtures: Electronic type.
   1. Operating Modes: Ballast circuit and leads provide for remote co of the associated lamp between high- and low-level and off.
      a. High-Level Operation: 100 percent of rated lamp lumens.
      b. Low-Level Operation: 30 percent of rated lamp lumens.
   2. Ballast shall provide equal current to each lamp in each operating mode.
   3. Compatibility: Certified by manufacturer for use with specific bi-level control lamp type indicated.

2.05 BALLASTS FOR COMPACT-FLUORESCENT LAMPS

A. Description: electronic programmed start type, complying with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated:
   1. Lamp end-of-life detection and shutdown circuit.
   2. Automatic lamp starting after lamp replacement.
   3. Sound Rating: A.
   4. Total Harmonic Distortion Rating: Less than 20 percent.
   5. Transient Voltage Protection: IEEE C62.41, Category A or better.
   6. Operating Frequency: 20 kHz or higher.
   7. Lamp Current Crest Factor: 1.7 or less.
   8. BF: 0.95 or higher, unless otherwise indicated.
   9. Power Factor: 0.95 or higher.
   10. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.
   11. Ballast Case Temperature: 75 deg C, maximum.

B. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic Type
   1. Dimming Range: 100 to 5 percent of rated lamp lumens.
   2. Ballast Input Watts: Can be reduced to 20 percent of normal.
   3. Compatibility: Certified by manufacturer for use with specific di lamp type indicated.

C. Electronic Ballast for Metal-Halide Lamps: Include the following features unless otherwise indicated:
   1. Lamp end-of-life detection and shutdown circuit.
   2. Sound Rating: A.
   3. Total Harmonic Distortion Rating: Less than 15 percent.
   4. Transient Voltage Protection: IEEE C62.41, Category A or better.
   5. Lamp Current Crest Factor: 1.5 or less.
   6. Power Factor: .90 or higher.
   7. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.
   8. Protection: Class P thermal cutout.
   9. Retain subparagraph and associated subparagraphs below for bi-level ballasts.
   10. Bi-Level Dimming Ballast: Ballast circuit and leads provide for remote control of the light output of the associated fixture between high- and low-level and off.
      a. High-Level Operation: 100 percent of rated lamp lumens.
      b. Low-Level Operation: 35 percent of rated lamp lumens.
      c. Compatibility: Certified by ballast manufacturer for use with specific bi-level control system and lamp type indicated. Certified by lamp manufacturer that ballast operating modes are free from negative effect on lamp life and color-rendering capability.
   11. Continuous Dimming Ballast: Dimming range shall be from 100 to 35 percent of rated lamp lumens without flicker.
      a. Ballast Input Watts: Reduced to a maximum of 50 percent of normal at lowest dimming setting.
      b. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated. Certified by lamp manufacturer that ballast operating modes are free from negative effect on lamp life and color-

rendering capability.

12. Auxiliary Instant-On Quartz System: Factory-installed feature automatically switches quartz lamp on when fixture is initially energized and when power outages occur. System automatically turns quartz lamp off when HID lamp reaches approximately 60 percent light output.

2.06 EXIT SIGNS

A. Description: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction. Comply with NEC, NC Building Code, Volume X Energy Code, NFPA-101, and NEMA Standards.

B. Internally Lighted Signs:
   1. Lamps for AC Operation: LEDs, 70,000 hours minimum rated lamp life. Maximum LED failure rate shall be 25 % within seven (7) year period, otherwise, if exceeded manufacturer shall replace the complete unit at no charge to the Owner.

2.07 FLUORESCENT LAMPS

A. Low-Mercury Lamps: Comply with EPA's toxicity characteristic leaching procedure test: shall yield less than 0.2 mg of mercury per liter when tested according to NEMA LL 1.

B. T8 programmed start lamps, rated 32 W maximum, nominal length of 1200 mm (48 inches), 2800 initial lumens (minimum), CRI 75 (minimum), color temperature 3500 K, and average rated life 20,0 hours, unless otherwise indicated.

C. T8 programmed start lamps, rated 17 W maximum, nominal length of 600 mm (24 inches), 1300 initial lumens (minimum), CRI 75 (minimum), color temperature 3500 K, and average rated life of 20,000 hours, unless otherwise indicated.

D. T5 programmed start lamps, rated 28 W maximum, nominal length of 45.2 inches, 2900 initial lumens (minimum), CRI 85 (minimum), color temperature 3500K, and average ated life of 20,000 hours, unless otherwise indicated.

E. T5HO programmed start, high-output lamp inches, 5000 initial lumens (minimum), CRI 85 (minimum), color temperature 3000K, and average average rated life of 20,000 hours, unless otherwise indicated.

F. Compact Fluorescent Lamps: 4-Pin, CRI 80 (minimum), color temperature 3500K, average rated life of 10,000 hours at 3 hours operation per start, unless otherwise in
   1. 13 W: T4, double or triple tube, rated 900 initial lumens (minimum).
   2. 18 W: T4, double or triple tube, rated 1200 initial lumens (minimum).
   3. 26 W: T4, double or triple tube, rated 1800 initial lumens (minimum).
   4. 32 W: T4, triple tube, rated 2400 initial lumens (minimum).
   5. 42 W: T4, triple tube, rated 3200 initial lumens (minimum).
   6. 55 W: T4, triple tube, rated 4300 initial lumens (minimum).

2.08 HID LAMPS

A. High-Pressure Sodium Lamps: ANSI C78.42, CR 21 (minimum) color temperature 1900K and average rated life of 24,000 hours, minimum.

1. Dual-Arc Tube Lamps: Arranged so only one of two arc tubes is lighted at one time an when power is restored after an outage, the cooler arc tube, with lower internal pressure, lights instantly, providing an immediate 8 to 15 percent of normal light output.

B. Metal-Halide Lamps: ANSI C78.1372, with a minimum CRI 65, and color temperature 4000 K

C. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and color temperature 4000 K.

2.09 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Division 16 Section "Electrical Supports and Seismic Restraints" for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

C. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.

2.10 RETROFIT KITS FOR FLUORESCENT LIGHTING FIXTURES

A. Comply with UL 1598 listing requirements.
1. Reflector kit: UL 1598, Type I. Suitable for two- to – four-lamp, surface mounted recessed lighting fixtures by improving reflectivity of fixture surfaces.
2. Ballast and lamp change kit: UL 1598, Type II. Suitable for changing existing ballast, lamps, and sockets.

3.00 EXECUTION

3.10 INSTALLATION

A. Lighting fixture: Set level, plumb, and square with ceilings and walls. Install lamps in each fuxture..

B. Support for Lighting Fixtures in or on Grid-Type Suspended Ceilings:
1. Where a recessed fluorescent , high intensity, or downlight fixture replaces a section or part of a ceiling tile, fixture is to be supported at the two (2) opposite ends to the steel frame of the building. Supports shall be provided with the same type of wire as used to support the lay-in ceiling track. Attach one end of the wire to one corner of the luminaire and the other end of the building's structural system.
2. The lay-in luminaire shall then be scewed to the main runners of the ay-in ceiling rack at all four (4) corners using sheet metal screws. For fire rated suspended ceiling, luminaire shall be supported to the building structure. The luminaire shall then be screwed to the main runners of the suspended ceiling track at all four (4) corners using sheet metal screws.

C. Suspended Lighting Fixture Support:
1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.

D. Air-Handling Lighting Fixtures: Install with dampers closed and ready for adjustment.

E. Adjust aimable lighting fixtures to provide required light intensities.

F. Connect wiring according to Division 16 Section "Conductors and Cables."

G. Installation of Interior Lighting Fixtures:

1. Install interior lighting fixtures at locations and heights as indicated, in accordance with fixture manufacturer's written instructions, applicable requirements of NEC, NECA's "Standard of Installation," NEMA standards, and with recognized industry practices to ensure that lighting fixtures fulfill requirements.
2. Provide fixtures and/or fixture outlet boxes with hangers to properly support fixture weight. Submit design of hangers, method of fastening, other than indicated or specified herein, for review by Engineer.
3. Install flush mounted fixtures properly to eliminate light leakage between fixture frame and finished surfaces.
4. Provide plaster frames for recessed fixtures installed in other than suspended grid type acoustical ceiling systems. Brace frames temporarily to prevent distortion during handling.
5. Fasten fixtures securely to indicated structural supports; and ensure that pendant fixtures are plumb and level. Provide individually mounted pendant fixtures longer than two (2') feet with twin stem hangers. Provide stem hanger with ball aligners and provisions for minimum one (1") inch vertical adjustment. Mount continuous rows of fixtures with an additional stem hanger greater than number of fixtures in the row. Provide clips for securing lay-in fixtures in grid ceiling system.
6. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Stds 486A and B, and the National Electrical Code.
7. Support surface mounted fixtures greater than two (2') feet in length at one other point in addition to the outlet box fixture stud.
8. Fixtures weighing more than 25 pounds shall be independently supported from the building structure, and shall not rely on ceiling or ceiling structure for support.
9. Surface mounted fluorescent fixtures shall be mounted using 1/4" threaded rod at each end and rods shall be attached to the building structure above the ceiling. Ceiling grid tees shall not be used for supporting surface mounted fixtures.

3.02 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

B. 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.

C. Replace defective and burned out lamps for a period of one year following the Date of Substantial Completion.

D. At Date of Substantial Completion, replace lamps in interior lighting fixtures which are observed to be noticeably dimmed after Contractor's use and testing, as judged by owner's representative, and architect/engineer of record.

E. Grounding:
   1. Provide equipment grounding connections for interior lighting fixtures as indicated specified in Section 16062 Grounding.
   2. Tighten connections to comply with tightening torques specified in UL Std 486A to assure permanent and effective grounds.

F. Adjusting and Cleaning:
   1. Clean interior lighting fixtures of dirt and construction debris upon completion of installation. Clean fingerprints and smudges from lenses.
   2. Protect installed fixtures from damage during remainder of construction period.

G. Demonstration:
   1. Upon completion of installation of interior lighting fixtures, and after building circuitr been energized, apply electrical energy to demonstrate capability and compliance with requirements.
   2. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

END OF SECTION 16511

SECTION 16521
EXTERIOR LIGHTING

1.00 GENERAL

1.01 SCOPE OF WORK

A. This Section includes the following:
   1. Exterior luminaires with lamps and ballasts.
   2. Luminaire-mounted photoelectric relays.
   3. Poles and accessories.

B. Extent of exterior lighting fixture work is indicated by the Drawings and Schedules.

C. Types of exterior lighting fixtures in this section include the following:
   1. High intensity discharge (HID).
   2. Metal halide.
   3. High pressure sodium.
   4. Fluorescent

D. Related Sections include the following:
   1. Division 16 Section "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of the building.

1.02 DEFINITIONS

A. CRI: Color-rendering index.

B. HID: High-intensity discharge

C. Luminaire: Complete lighting fixture, including ballast housing if provided.

D. Pole: Luminaire support structure, including tower used for large area illumination.

E. Standard: Same definition as "Pole" above.

1.03 STRUCTURAL ANALYSIS FOR POLE SELECTION

A. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices and supporting structure, applied as stated in AASHTO LTS-4.

B. Wind Load: Pressure of wind on pole and luminaire, calculated and applied as stated in AASHTO LTS-4.
   1. Wind speed for calculating wind load for poles 50 feet (15 meters) or less in height is 110 mph (177 kph).

1.04 SUBMITTALS

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:
   1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
   2. Details of attaching luminaires and accessories.
   3. Details of installation and construction.

4. Luminaire materials.
5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.
   a. For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaries shall be certified by manufacturer.
6. Photoelectric relays.
7. Ballasts, including energy-efficiency data.
8. Lamps, including life, output, and energy-efficiency data.
9. Materials, dimensions, and finishes of poles.
10. Means of attaching luminaries to supports, and indication that attachment is suitable for components. involved.
11. Anchor bolts for poles.

B. Shop drawings
   1. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
   2. Wiring Diagrams: Power wiring.
   3. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4 and that load imposed by luminaire has been included in design.

D. Operation and Maintenance Data: For luminaries and poles to include in emergency operation and maintenance manuals.

E. Warranty : Special warranty specified in this Section.

1.05 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited for evaluating energy efficient lighting products.

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

C. Comply with IEEE C2, "National Electrical Safety Code."

D. Comply with NFPA 70.

E. Manufacturers: Firms regularly engaged in manufacture of exterior building lighting fixtures of types and ratings required.

F. Codes and Standards:
   1. NEC Compliance: Comply with NEC as applicable to installation and construction of exterior building lighting fixtures.
   2. NEMA Compliance: Comply with applicable requirements of NEMA Stds Pub/No.'s FA 1, LE 1 and LE 2 pertaining to lighting equipment.
   3. Third Party Agency Compliance: Provide products which have been listed and/or labeled by a third party agency accredited by the NCBCC to label electrical and mechanical equipment as of August 1, 1991.
   4. ANSI Labels: Provide fluorescent lamp ballasts, which comply with ANSI C82.11.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B 660.

B. Store poles on decay-resistant-treated skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch deep. Do not apply tools to section of pole to be installed below ground line.

D. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

E. Handle lighting fixtures carefully to prevent damage, breaking, and scoring. Do not install damaged fixtures or components; replace with new.

F. Store lighting fixtures in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

1.07 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.

1. Warranty Period for Luminaires: One year from date of final acceptance of the work.
2. Warranty Period for Metal Corrosion: One year from date of final acceptance of the work..
3. Warranty Period for Color Retention: One year from date of final acceptance of the work..
4. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than one year from date of final acceptance of the work.

1.08 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least two of each type.
2. Glass and Plastic Lenses, Covers, and Other Optical Parts: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
3. Ballasts: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: 10 for every 100 of each type and rating installed. Furnish at least one of each type.

2.00 PRODUCTS

2.01 MANUFACTURERS

A. In Exterior Lighting Device Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

B. Subject to compliance with requirements, manufacturers offering products which may be incorporated into the work include, but are not limited to, the following:
   1. Exterior Lighting Fixtures:
      a. As scheduled on drawings.
   2. Fluorescent Ballasts:
      a. Advance Transformer Co.
      b. Jefferson Electric Co.
      c. Universal Mfg. Co.
      d. Valmont Industries, Inc.
   3. High Intensity Discharge Ballasts:
      a. Advance Transformer Co.
      b. General Electric Co. (Hendersonville)
      c. Holophane Div.; Johns-Manville Corp.
      d. Jefferson Electric Co.
      e. Universal Transformer Co.
   4. Lamps:
      a. General Electric
      b. Osram/Sylvania
      c. Philips

C. Exterior Lighting Fixtures:
   1. General: Provide lighting fixtures, of sizes, types and ratings indicated; complete with, but not limited to, housings, energy efficient ballasts, starters and wiring.
   2. Wiring: Provide electrical wiring within fixture suitable for connection to branch circuit wiring as follows:
   3. NEC Type AF for 120 volts, minimum No. 18 AWG.
   4. NEC Type SF-2 for 277 volts, minimum No. 18 AWG.

D. Fluorescent-Lamp Ballasts: Provide low-temperature, high power-factor, low energy fluorescent lamp ballasts, capable of operating lamp types indicated.

E. High-Intensity-Discharge Lamp Ballasts: Provide HID lamp ballasts, capable of operating lamp types with ratings indicated; reactor type, high power-factor, core and coil assembly encapsulated in non-melt resin; install capacitor outside ballast encapsulation for easy field replacement.

F. Provide HID lamp ballasts, which properly mates and matches lamps to electrical supply by providing appropriate voltages and impedances for which lamps are designed. Design ballasts to operate lamp within the lamp manufacturer's specifications.

G. Lamps:
   1. All lamps of a particular type used on this Project shall be by one manufacturer.
   2. All lamps of a particular type shall be from one production run.
   3. Provide fluorescent lamps of energy saving types and wattages as indicated on the Drawings.
   4. Provide HID lamps in types and wattages indicated on the Drawings.
   5. Provide incandescent lamps in types and wattages as indicated on the Drawings.

H. Exterior Lighting Fixture Types:
   1. General: Refer to the Fixture Schedule for types and requirements of exterior lighting fixtures.

I. Execution:
   1. Inspection:
      a. Examine areas and conditions under which lighting fixtures are to be installed, and substrate which will support lighting fixtures.
      b. Do not proceed with work until unsatisfactory conditions have been corrected.

2.02 LUMINAIRES, GENERAL REQUIREMENTS

A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

B. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

C. Metal Parts: Free of burrs and sharp corners and edges.

D. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.

E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.

G. Exposed Hardware Material: Stainless steel.

H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

I. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

J. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
   1. White Surfaces: 85 percent.
   2. Specular Surfaces: 83 percent.

3. Diffusing Specular Surfaces: 75 percent.

K. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

L. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and - tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

M. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
a. Color: As selected from manufacturer's standard catalog of colors.

N. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
a. Color: Medium bronze.

2.03 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

A. Comply with UL 773 or UL 773A.

B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay.
1. Relay with locking-type receptacle shall comply with NEMA C136.10.
2. Adjustable window slide for adjusting on-off set points.

2.04 FLUORESCENT BALLASTS AND LAMPS

A. Low-Temperature Ballast Capability: Rated by its manufacturer for reliable starting and operation of indicated lamp(s) at temperatures 0 deg F and higher.

B. Ballast Characteristics:
   1. Power Factor: 90 percent, minimum.
   2. Total Harmonic Distortion Rating: Less than 10 percent.
   3. Electromagnetic Ballasts: Comply with ANSI Class P, automatic-reset thermal protection.
   4. Case Temperature for Compact Lamp Ballasts: 65 deg C, maximum.
   5. Transient-Voltage Protection: Comply with IEEE C62.41 Category A or better.

C. Low-Temperature Lamp Capability: Rated for reliable starting and operation with ballast provided at temperatures 0 deg F and higher.

D. Fluorescent Lamps: Low-mercury type. Comply with the EPA's toxicity characteristic leaching procedure test; shall yield less than 0.2 mg of mercury per liter when tested according to NEMA LL 1.

2.05 BALLASTS FOR HID LAMPS

A. Comply with ANSI C82.4 and UL 1029 and capable of open-circuit operation without reduction of average lamp life. Include the following features unless otherwise indicted:
   1. Ballast Circuit: Constant-wattage autotransformer or
   2. Minimum Starting Temperature: Minus 22 deg F.
   3. Normal Ambient Operating Temperature: 104 deg F.

B. Auxiliary, Instant-On, Quartz System: Factory-installed feature automatically switches quartz lamp on when fixture is initially engrized and when momentary power outages occur. System automatically turns quartz lamp off when HII lamp reaches approximately 60 percent of light output.

C. High-Pressure Sodium Ballasts: Electromagnetic type with solid-state igniter/starter and capable of open-circuit operation without reduction of average lamp life. Igniter/starter shall have an average life in ulsing mode of 10,000 hours at an igniter/starter –case temperature of 90 deg C.
   1. Instant- Restrike Device: Integral with ballast, or solid-state potted module, factory installed within fixture and compatible with lamps, ballasts, and mogul sockets up to 150 W.
      a. Restrike range: 105- to 130- V ac.
      b. Maximum Voltage: 250-V peak or 150-V ac RMS.

2.06 HID LAMPS

A. High-Pressure Sodium Lamps: ANSI C78.42, CRI 21 (minmum), color temperature 1900 K, and average rated life of 24,000 hours, minimum.

B. Metal-Halide Lamps: ANSI C78.1372, with a minimum CRI 65, and color temperature 4000K.

C. Pulse Start, Metal-Halide Lamps: Minimum CRI 65, and color temperature 4000K

2.07 POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS

A. Structural Characteristics: Comply with AASHTO LTS-4.
   1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure permanent deflection, or whipping in steady winds of speed

indicated in Part 1 "Structural Analysis Criteria for Pole Selection" Article, with a gust factor of 1.3.

2. Strength Analysis: For each pole, multiply the actual projects area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.

B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts, unless otherwise indicated.

C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
   1. Materials: Shall not cause galvanic action at contact points.
   2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication, unless stainless steel items are indicated.
   3. Anchor-Bolt Template: Plywood or steel.

D. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 3 Section "Cast-In-Place" concrete.

E. Breakaway Supports: Frangible breakaway supports, tested by an independent agency acceptable to the owner and construction manager, according to AASHTO LTS-4.

F. All metal poles shall be provided with a gasketed handhole in the pole to access branch circuit wiring. Access fasteners shall be vandal-resistant.

2.08 STEEL POLES

A. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 p1-piece construction up to 40 feet 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.

B. Steel Mast Arms: Single-arm type, continuously welded to pole attachment plate. Material and finish same as pole.

C. Brackets for Luminaires: detachable, cantilever, without underbrace.
   1. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.
   2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
   3. Match pole material and finish.

D. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fasten to pole top.

E. Steps: Fixed steel, with nonslip treads, positioned for 380 mm (15-inch) vertical spacing, alternating opposite sides of pole; first step at elevation 3meters (10 fee)t above finished grade.

F. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with

requirements in Division 16 Section "Grounding and Bonding," listed for attaching grounding and bonding conductors of type and size listed in that Section, accessible through handhole.

G. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable time a 5.0 safety factor.

H. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
   1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, “Solvert Cleaning”, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to smooth even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
   2. 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: Match Arc

2.09 POLE ACCESSORIES

A. Base Covers: Manufacturer’ standard metal units, arranged to cover pole’s mounting bolts and nuts. Finish same as pole/

3.00 EXECUTION

3.01 I NSTALLATION OF EXTERIOR LIGHTING FIXTURES

A. Install exterior lighting fixture at locations and heights as indicated, in accordance with fixture manufacturer’s written instructions, applicable requirements of NEC, NECA’s “Standards of Installation,” NEMA standards, and with recognized industry practices to ensure that lighting fixtures fulfill requirements.

B. Coordinate with other electrical work as appropriate to properly interface installation of exterior lighting fixtures with other work.
   1. Tighten connectors and terminals, including screws and bolts, to comply with tightening torques specified in UL Stds 486A and B.
   2. Fasten fixtures securely to poles, and ensure that poles and fixtures are plumb.

C. Adjusting and Cleaning:
   1. Clean exterior lighting fixtures or dirt and debris upon completion of installation.
   2. Protect installed fixtures from damage during construction period.

3.02 LUMINAIRE INSTALLATION

A. Install lamps in each luminaire.

B. Fasten luminaire to indicated structural supports.

1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by the manufacturer.

C. Adjust luminaires that require field adjusting or aiming.

3.03 POLE INSTALLATION

A. Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features, unless otherwise indicated on Drawings:
   1. Fire hydrants and storm drainage piping: 1524 mm (60 inches)
   2. Water, electric, communication, gas an sewer lines: 3000 mm (10 feet)
   3. Trees: 4600 mm (15 feet)

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 Division 3 Section "Cast-in-Place Concrete."

D. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
   1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
   2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
   3. Install base covers, unless otherwise indicated.
   4. Use a short piece of ½ inch 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 minimum of 150 mm (6 inch) wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 25 mm (1 inch) below top of concrete slab.

F. Raise and set poles using web fabric slings (not chain or cable).

3.04 BOLLARD LUMINAIRE INSTALLATION

A. Align units for optimum directional alignment of light distribution.

B. Install on concrete base with top flush with finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 3 Section "Cast-in-Place Concrete."

3.05 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

A. Install on concrete base with top flush with 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 Division 3 Section "Cast-in-Place Concrete."

3.06 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 Division 16 Section "Raceways and Boxes." In concrete foundations, wrap conduit with 0.010 inch thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.07 GROUNDING

A. Ground metal poles and support structures according to Division 16 Section "Grounding and Bonding."
   1. Install grounding electrode for each pole, unless otherwise indicated.
   2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

B. Ground nonmetallic poles and support structures according to Division 16 Section "Grounding and Bonding."
   1. Install grounding electrode for each pole.
   2. Install grounding conductor and conductor protector.
   3. Ground metallic components of pole accessories and foundations.

C. Tighten connections to comply with tightening torques specified in UL Std 486A to assure permanent and effective grounds.

D. Provide equipment grounding connections for exterior lighting fixtures as indicated and as specified in Section 16452 Grounding.

3.08 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.
   1. Verify operation of photoelectric controls.

C. Illumination Tests:
   1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IESNA testing guide(s):
      a. IESNA LM-5, "Photometric Measurements of Area and Sports Lighting."
      b. IESNA LM-50, "Photometric Measurements of Roadway Lighting Installations."
      c. IESNA LM-52, "Photometric Measurements of Roadway Sign Installations."
      d. IESNA LM-64, "Photometric Measurements of Parking Areas."
      e. IESNA LM-72, "Directional Positioning of Photometric Data."

D. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

E. Upon completion of installation of exterior lighting fixtures, and after building circuitry has been energized, apply electrical energy to demonstrate capability and compliance with requirements.

F. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with

retesting.

G. Replace defective and burned out lamps for a period of one year following the Date of Substantial Completion.

H. At the Date of Substantial Completion, replace lamps in exterior lighting fixtures which are observed to be noticeably dimmed after Contractor's use and testing as judged by the Engineer.

END OF SECTION 16521

SECTION 16715
VOICE AND DATA COMMUNICATION CABLING

1.00 GENERAL

1.01 GENERAL DESCRIPTION

All electrical works for voice and data communication cabling for this project shall be governed by the provisions of the latest edition of the Philippine Electrical Code, rules and regulations of Local Authorities that have jurisdiction over the project and policies of electric and communication utility companies in the locality.

1.02 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

A. ELECTRONIC INDUSTRIES ASSOCIATION (EIA)
   1. EIA TSB-67 Transmission Performance Specifications for Field Testing of Unshielded Twisted-Pair Cabling Systems
   2. EIA 310-D Cabinets, Racks, Panels, and Associated Equipment
   3. EIA/TIA TSB-75 Additional Horizontal Cabling Practices for Open Offices
   4. EIA-455-21A FOTP-21 Mating Durability of Fiber Optic Interconnecting Devices
   5. EIA-492AAAA-A 50 Micrometer Core Diameter/125-Micrometer Cladding Diameter Class 1a Graded-Index Multimode Optical Fibers
   6. EIA/TIA-526-7 OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
   7. EIA/TIA-526-14 OFSTP-14 Optical Power Loss Measurements of Installed Multimode Fiber Cable

B. Plant
   1. EIA/TIA-568-C Addendum 1997, Addendum 1998) Commercial Building Telecommunications Wiring Standard
   2. EIA/TIA-569-A Commercial Building Standard for Telecommunications Pathways and Spaces
   3. EIA/TIA-606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
   4. EIA/TIA-607 Commercial Building Ground and Bonding Requirements for Telecommunications

C. INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)
   1. ANSI/ICEA S-80-576 Communication Wire and Cable for Wiring of Premises

D. NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)
   1. NEMA WC 63.1 Telecommunications Cables

E. NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
   1. NFPA 70 National Electrical Code

F. UNDERWRITERS LABORATORIES INC. (UL)
   1. UL 444 Communications Cables
   2. UL 467 Grounding and Bonding Equipment
   3. UL 497 Safety Protector for Paired Conductor Communication Circuit
   4. UL 514C Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers

5. UL 910 Flame-Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environmental Air
6. UL 969 Marking and Labeling Systems
7. UL 1286 Office Furnishings
8. UL 1581 Electrical Wires, Cables, and Flexible Cords
9. UL 1666 Flame Propagation Height of Electrical and Optical-Fiber Cables Installed in Vertical Shafts
10. UL 1863 Communication Circuit Accessories

1.03 SUMMARY

A. This Section includes the following items for wiring systems used as signal pathways for voice and high-speed data transmission:
   1. Mounting elements.
   2. Unshielded twisted-pair cabling.
   3. Fiber-optic cabling.
   4. Coaxial cable.
   5. Multiuser telecommunications outlet assemblies.
   6. Workstation outlets.
   7. Backboards.
   8. Identification products.

B. Related Sections include the following:
   1. Division 13 Section "Security Access" for data transmission meeting RS-232 and RS-485 cabling associated with system panels and devices.

C. The structured telecommunications cabling and pathway system shall include permanently installed backbone and horizontal cabling, horizontal and backbone pathways, service entrance facilities, work area pathways, telecommunications outlet assemblies, conduit, raceway, and hardware for splicing, terminating, and interconnecting. The horizontal system includes the cabling and pathway between the telecommunications closet and the work area telecommunications outlet. The horizontal system shall be wired in a star topology with the IDF at the center or hub of the star. The backbone cabling and pathway system includes intrabuilding interconnecting cabling, pathway, and terminal hardware to provide connectivity between the MDF's, BDF's, and IDF's. The backbone system shall be wired in a star topology with the MDF at the center or hub of the star.

1.04 DEFINITIONS

A. Backbone: A facility (e.g., pathway, cable, or conductors) between telecommunications rooms or floor distribution terminals, the entrance facilities, and the equipment rooms within or between buildings.
B. BICSI: Building Industry Consulting Service International.
C. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
D. EMI: Electromagnetic interference.

E. Horizontal Cabling: Cabling between and including the telecommunications outlet/connector and the horizontal cross-connect. Also the cabling between and including the building automation system outlet or the first mechanical terminations on the horizontal connection point and the horizontal cross-connect.

F. IDC: Insulation displacement connector.

G. LAN: Local area network.

H. RCDD: Registered Communications Distribution Designer.

I. RMC: Rigid metallic conduit.

J. UTP: Unshielded twisted pair.

K. Main Distribution Frame (MDF): A physical structure at a central location for terminating permanent backbone cables to interconnect with service provider (SP) equipment at the activity minimum point of presence. The MDF generally includes vendor specific components to support voice and data circuits, building surge protector assemblies, main cross connect blocks, equipment support frames, and wood backboard (if MDF is wall mounted). Depending upon local site conditions, the MDF and BDF may be identical.

L. Building Distribution Frame (BDF): A structure with terminations for connecting backbone, campus, and horizontal cabling. The BDF generally includes a cross connect, equipment support frame, and wooden backboard or terminal cabinet. The BDF shall

M. Intermediate Distribution Frame (IDF): An intermediate termination point for horizontal wiring and cross connections within telecommunications closets or wiring closets.

N. Telecommunications Closet: An enclosed space for telecommunications equipment, terminations, and cross-connect wiring for horizontal cabling.

1.05 SUBMITTALS

A. Product Data: For features, ratings, and performance of each component specified.
   1. For coaxial cable, include the following installation data for each type used:
      a. Nominal OD.
      b. Minimum bending radius.
      c. Maximum pulling tension.

B. Shop Drawings:
   1. Include dimensioned plan and elevation views of telecommunications equipment rooms, labeling each individual component. Show equipment rack assemblies, method of field assembly, workspace requirements, and access for cable connections.
   2. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
   3. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
   4. Cabling Administration Drawings.
   5. Wiring diagrams to show typical wiring schematics including the following:
      a. Workstation outlets, jacks, and jack assemblies.
      b. Patch cords.
      c. Patch panels.
      d. Fiber-optic boxes.
      e. Distribution racks.
      f. Terminal racks.

C. Manufacturer Seismic Qualification Certification: Submit certification that distribution racks, patch panels, and their components will withstand seismic forces defined in Division 16 Section "Electrical Supports and Seismic Restraints." Include the following:
   1. Basis for Certification: Base certification on the maximum number of components capable of being mounted in each rack type. Identify components on which certification is based. 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 of each rack-mounted component and of each assembled rack type, and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Qualification Data: For Installer.

E. Source quality-control test reports.

F. Field quality-control test reports.

G. Submit the following in accordance with Conditions of Contract and Division 1 specification sections.
   1. Shop Drawings
   2. Telecommunications drawings
   3. Distribution frames
   4. Product Data
   5. Telecommunications cabling (backbone and horizontal)
   6. Patch panels
   7. Telecommunications outlet/connector assemblies
   8. Equipment support frame
   9. Building protector assemblies
   10. Connector blocks
   11. Protector modules
   12. Test Reports
   13. Telecommunications cabling testing
   14. Factory reel tests for optical fiber cables
   15. Certificates
   16. Installer qualifications
   17. Test plan
   18. Operation and Maintenance Data
   19. Telecommunications cabling and pathway system Data Package.

H. ADDITIONAL SUBMITTAL REQUIREMENTS
   1. Telecommunications Drawings & Electronic Files
   2. Provide registered communications distribution designer (RCDD) approved drawings complete with wiring diagrams and details required to prove that the distribution system shall properly support connectivity from the telecommunications equipment room to telecommunications work area outlets. Show the entrance facility and layout of cabling and pathway runs, cross connect points, MDF, BDF, IDF, grounding system, terminating block arrangements and

type. Drawings shall depict final telecommunications cabling configuration, including location, color coding, gage, pair assignment, polarization, and terminating blocks layout at cross connect points and patch panels after telecommunications cable installation. Provide a plastic laminated schematic of telecommunications cable system showing cabling, BDF's, IDF's, MDF's, and equipment rooms keyed to floor plans by room number. All required design, testing, termination and labeling information is to be provided in electronic format on CD ROM in addition to hard copy format.

3. Distribution Frames

4. Provide shop drawing showing layout of applicable equipment including incoming cable stub or connector blocks, building protector assembly, outgoing cable connector blocks and equipment spaces and racks. Provide all information on CD ROM in electronic format and in hard copy file.

5. Installer Qualifications

6. Prior to installation, submit data of installer's experience and qualifications. Installers shall be a Building Industry Consulting Service International (BICSI) Registered Cabling Installation Technician or have experience which shall include 3 years on projects of similar complexity. Include names and locations of two projects successfully completed using optical fiber and] copper communications cabling systems. Include written certification from users that systems have performed satisfactorily for not less than 18 months. Include specific experience in installing and testing structured telecommunications distribution systems using optical fiber, Category 3 and Category 6 cabling systems.

7. Test Plan

8. Provide a complete and detailed test plan for the telecommunications cabling system including a complete list of test equipment for the UTP and optical fiber components and accessories. Include procedures for certification, validation, and testing.

9. Additions to Operation and Maintenance Manuals

10. In addition to requirements of Data Package 6 for the telecommunications cabling and pathway system, including the requirements of paragraph entitled "Telecommunications Drawings".

1.05 DELIVERY AND STORAGE

A. Provide protection from weather, moisture, dirt, dust, and other contaminants for telecommunications cabling and pathway equipment placed in storage.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: Cabling installer must have on staff personnel certified by BICSI.

1. Layout Responsibility: Preparation of Shop Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of a Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.

C. Testing Agency's Field Supervisor: Person currently certified by BICSI as an RCDD to supervise field quality-control testing.

D. Source Limitations: Obtain all products except cables through one source from a single manufacturer.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

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

G. Comply with EIA/TIA Standards, latest editions.

2.00 PRODUCTS

2.01 ACTIVE COMPONENTS

A. Active components are not part of the project scope.

2.02 PASSIVE COMPONENTS

A. UL or third party certified. Provide a complete system of telecommunications cabling and pathway components using star topology and support structures, patch panels, connectors, fiber optic cabling, category 6 cabling, racks, pathways, and space complete with conduits, pull wires, wireways, cable trays, terminal boxes, outlets, cables, junction boxes, telephone cabinets, and telecommunications closets. Fixed cables and pathway systems for telecommunications system shall be UL listed or third party independent testing laboratory certified, and shall comply with NFPA 70.

2.03 PATHWAYS (BACKBONE AND HORIZONTAL)

A. EIA/TIA-569-A. Pathway shall be conduit and cable tray (in telecommunication equipment rooms and telecommunications closets only. Provide grounding and bonding as required by EIA/TIA-607. Cable tray wiring shall comply with NFPA 70.

B. Work Area Pathways

C. Comply with EIA/TIA-569-A. System furniture pathways shall comply with UL 1286. Horizontal cabling for open offices shall comply with EIA/TIA TSB-75.

2.04 TELECOMMUNICATIONS CABLING

A. Cabling shall be UL listed for the application and shall comply with EIA TBS-67, EIA/TIA-568-C and NFPA 70. Provide a labeling system for cabling as required by EIA/TIA-606

and UL 969. Cabling manufactured more than 12 months prior to date of installation shall not be used.

B. Backbone Cabling

1. Backbone Copper (telephone)
   a. Acceptable Manufacturers: Belden, Mohawk, BICC, General Cable
   b. ANSI/ICEA S-80-576, EIA/TIA-568-C and UL 444, copper backbone cable shall be solid conductor, 24 AWG, 100 ohm, 100 - pair UTP (Unshielded twisted pair), NFPA 70 CMR rated formed into 25 pair binder groups covered with a gray thermoplastic jacket. NFPA 70 type CMP may be substituted for type CMR. Pair twist lengths and frequency per unit length shall be determined by the manufacturer. A minimum of two conductor twists per foot is required. Color coding shall comply with industry standards for 25 pair cables. Cable shall be third party verified to comply with EIA/TIA requirements.
2. Backbone Optical Fiber
   a. Acceptable Manufacturers: Mohawk, Berk-Tek, Siecor
   b. EIA-492AAAA-A, UL 1666, optical fiber cable shall be 50/125
   c. 12-fiber multimode and 6-fiber single mode with a NFPA 70 rating of OFNR. NFPA 70 type OFNP may be substituted for type OFNR. The cable jacket shall be orange.
   d. he cable shall provide a maximum attenuation of 3.5 dB/km @ 850 nm and 1.0 dB/km @ 1300 nm. The bandwidth of the cable shall be 160 MHz-km @ 850 nm and 500 MHz-km @ 1300 nm.

C. Horizontal Cabling

1. Comply with NFPA 70, NEMA WC 63.1, ANSI/ICEA S-80-576, EIA TSB-67 and performance characteristics in EIA/TIA-568-C.
2. Cable length maximum is 90 meters (295 feet) for UTP Level 6 from the horizontal cross-connect
3. To the outlet/connector and 20 feet for patch cords and cross-connect jumpers in the horizontal cross-connect.
4. In establishing limits on horizontal cable lengths, a 33 ft. allowance was made for combined length of patch cables and cables used to connect equipment in the work area and telecommunications closet. All equipment cables should meet or exceed the same performance requirements as the patch cords.
5. The 20 ft. maximum length specified for patch cables does not include additional cable lengths needed to connect to active equipment. For example, if 3m (10 ft.) of cable is used for each work area connection, the 33 ft. total allowance provides for up to 23 ft. of combined length per channel for patch cables and equipment cables in the telecommunications closet.

D. Horizontal Copper

1. Acceptable Manufacturers:
   a. Belden
   b. Mohawk
   c. BICC
   d. General Cable

e. AMP, a Tyco International Ltd. Company

2. UTP (unshielded twisted pair), 100 ohm. Provide four each individually twisted pair, 24 AWG conductors, NFPA 70 CMG rated, with a blue PVC jacket. NFPA 70 type CMP or CMR may be substituted for type CMG. Individual pairs shall be constructed to contain a minimum two twists per foot per each pair. Overall diameter of four pair cable shall not exceed .25 inches. Ultimate breaking strength shall be minimum 40.82 kg 90 pounds. Four pair cable shall withstand a bend radius of one inch minimum at a temperature of minus 20 degrees C maximum without jacket or insulation cracking. Conductors shall be color coded and polarized in accordance with EIA/TIA-568-C. Horizontal cabling in open offices shall comply with EIA/TIA TSB-75.
3. Category 6 UTP,UL listed and third party verified to comply with EIA/TIA-568-C Category 6 requirements.
4. Category 3 UTP shall be third party verified to comply with EIA/TIA-568-C Category 3 requirements.

2.05 DISTRIBUTION FRAMES

A. Provide building distribution frames (BDFs), intermediate distribution frames (IDFs), and main distribution frames (MDFs) as shown on design drawings for terminating and cross connecting permanent cabling.

B. Equipment Support Frame

1. EIA 310-D.

C. Racks, floor mounted modular type, 16-gauge steel construction treated to resist corrosion. Provide rack with vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug and a surge protected power strip with 6 duplex 20 amp receptacles. Rack shall be compatible with 19 inches panel mounting. Provide Chatsworth or approved equal.

D. Building Protector Assemblies

1. Self-contained unit providing a field cable stub factory connected to protector socket blocks to terminate and accept protector modules for 200 pairs of outside cable. Building protector assembly shall have connector blocks for connection to interior cabling at full capacity.

E. Protector Modules

1. UL 497, RUS TECM 823, solid state type rated for the application. Provide the number of surge protector modules equal to the number of pairs of exterior cable of the building protector assembly. Provide Panamax or approved equal.

F. Connector Blocks

1. Insulation displacement Type 110 for Category 6 and higher systems. Provide blocks for the number of horizontal and backbone cables terminated on the block plus 25 percent spare.

G. Patch Panels

1. Provide ports for the number of horizontal and backbone cables terminated on the panel plus 25 percent spare. Provide pre-connectorized Optical fiber and copper

patch cords for patch panels. Provide patch cords with connectors specified. Patch cords shall meet minimum performance requirements specified in EIA/TIA-568-C for cables and hardware specified.

2. Modular to 110 Block Patch Panel
3. Panels shall be amp, Sieman or pandiut and shall comply with EIA/TIA-568-C. Panels shall be third party verified and [shall comply with EIA/TIA category 6 requirements. Panels shall be constructed of .09 inch minimum aluminum and shall be compatible with an EIA 19 inch equipment rack. Panel shall provide 48 non-keyed, RJ-45 ports, wired to T568A standards as required. Patch panels shall terminate the building cabling on 110-style insulation displacement connectors and shall utilize a printed circuit board interface. The rear of each panel shall have incoming cable strain-relief and routing guides. Panels shall have each port factory numbered and be equipped with laminated plastic nameplates above each port.
4. Fiber Optic Patch Panel
   a. Panel shall be amp, Sieman or Panduit. Provide panel for maintenance and cross-connecting of optical fiber cable. Panel shall be constructed of 0.09 inch minimum aluminum and shall be compatible with a 19 inch equipment rack. Each panel shall provide 24 duplex SC multimode adapters. Adapters shall utilize zirconia ceramic alignment sleeves. Provide dust cover for all unused adapters. The rear of each panel shall have a cable management tray a minimum of 8 inches deep with removable cover, incoming cable strain-relief and routing guides. Panels shall have each adapter factory numbered and be equipped with laminated plastic nameplates above each adapter.

2.06 TELECOMMUNICATIONS OUTLET BOXES

A. Standard type 4 inches square by 2 1/8 inches deep. Mount flush in finished walls at height indicated or as specified for outlet receptacles. Outlet boxes for wall-mounted telephones shall be 2 by 4 by 2 1/8 inches deep, mounted at height as indicated. Depth of boxes shall be large enough to allow manufacturers' recommended conductor bend radiuses.

2.07 TELECOMMUNICATIONS OUTLET/CONNECTOR ASSEMBLIES:

A. Outlet/Connector Copper

B. Outlet/connectors shall be amp, Sieman or panduit and shall comply with FCC Part 68.5, and EIA/TIA-568-C. UTP Outlet/connectors shall be UL 1863 listed, non-keyed, 4-pair, constructed of high impact rated thermoplastic housing and shall be third party verified and CAT 6 requirements. Each jack shall be wired T568A. UTP outlet/connectors shall comply with EIA-455-21A for 500mating cycles.

C. Optical Fiber Adapters

1. Optical fiber adapters shall be amp Sieman or Panduit and shall be suitable for duplex SC style connectors. Adapters shall utilize zirconia ceramic alignment sleeves. Provide dust cover for all adapters.

D. Cover Plates

1. Telecommunications cover plates shall comply with UL 514C, and; oversized design constructed of 302 stainless material. Stenciled lettering for voice and data circuits shall be provided using thermal ink transfer process.

E. Optical Fiber Connectors

1. Connectors shall be amp, Sieman or Panduit and shall comply with EIA-455-21A. Optical fiber connectors shall be Type “ST”. The connectors shall provide a maximum attenuation of .3 dB @ 1300 nm with less than a 0.2 dB change after 500 mating cycles.

2.08 BACKBOARDS:

A. Provide void-free, fire rated interior grade plywood 19 mm ¾ inch thick [4 by 8 feet] [as indicated]. Backboards shall be painted with a gray, nonconductive fire-resistant overcoat. Do not cover the fire stamp on the backboard.

2.09 GROUNDING AND BONDING PRODUCTS:

A. Comply with UL 467, EIA/TIA-607, and NFPA 70. Components shall be

B. Identified as required by EIA/TIA-606.

2.10 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.11 SYSTEM REQUIREMENTS

A. Coordinate the features of materials and equipment so they form an integrated system. Match components and interconnections for optimum future performance.

B. Expansion Capability: Unless otherwise indicated, provide spare fibers and conductor pairs in cables, positions in cross-connect and patch panels, and terminal strips to accommodate 20 percent future increase in the number of workstations shown on Drawings. This expansion requirement does not apply to horizontal cable from workstation outlet to first terminal board.

2.12 MOUNTING ELEMENTS

A. Backboards: 3/4-inch, interior-grade, fire-retardant-treated plywood.

B. Distribution Racks: Freestanding and wall-mounting, modular-steel units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.

1. Module Dimension: Width compatible with EIA 310 standard 19-inch panel mounting.
2. Finish: Baked-polyester powder coat.

C. Power Strips: For mounting in the racks, with (21) NEMA 5-20R and (6) L6-20R equivalent to APC zero U 5.7KW 120/208V.:

1. LED indicator lights for power and protection status.
2. LED indicator lights for reverse polarity and open outlet ground.

3. Circuit breaker and thermal fusing. When protection is lost, circuit opens and cannot be reset.
4. Close-coupled, direct plug-in line cord.
5. Rocker-type on-off switch, illuminated when in on position.
6. Peak Single-Impulse Surge Current Rating: 33 kA per phase.
7. Protection modes shall be line-to-neutral, line-to-ground, and neutral-to-ground. UL 1449 clamping voltage for all 3 modes shall be not more than 330 V.
8. One RJ11/12C telephone line protector, suitable for modem connection. Maximum clamping voltage 220 peak on pins No. 3 and No. 4.

D. Floor-Mounting Rack: Steel, freestanding, modular, with vertical and horizontal cable management channels, top and bottom cable troughs, and grounding lug.

E. Cabinets: Steel, freestanding, modular, with removable and lockable side panels, front and rear doors, ventilation openings in rear door and top panel, and the following components:
1. Provisions for a roof-mounted ventilation fan.
2. 250-cfm roof-mounted ventilation fan.
3. Key all locks alike.

2.13 UNSHIELDED TWISTED-PAIR CABLING

A. Cable Manufacturers:
1. Belden Inc.; Electronics Division.
2. CommScope Properties, LLC.
3. General Cable Technologies Corporation.
4. Mohawk/CDT; a division of Cable Design Technologies.
5. Nordex/CDT, a Subsidiary of Cable Design Technologies.
6. AMP, a Tyco International Ltd. Company

B. Terminal and Connector Component and Distribution Rack Manufacturers:
1. AMP; a Tyco International Ltd. Company.
2. Hubbell Premise Wiring.
3. Leviton Voice & Data Division.
4. Panduit Corp.
5. Belden Inc; Electronics Division

C. 100-Ohm UTP: Comply with UL 444.

D. Backbone Copper Cable:
1. No. 24 AWG, 25 pair.
2. Category 3
3. NFPA 70, type CMR complying with UL 1666.
4. Cable Jacket Color: Gray.

E. Horizontal Copper Cable:
1. No. 24 AWG, 100 ohm, four pair.
2. Comply with TIA/EIA-568-C, Category 6
3. NFPA 70, types CMG and CMP.
4. Cable Jacket Color: Blue.

F. Cable Connecting Hardware: Comply with TIA/EIA-568-C, IDC type, using modules designed for punch-down caps or tools.
1. IDC Terminal Block Modules: Integral with connector bodies, including plugs and jacks where indicated.
2. IDC Connecting Hardware: Consistent throughout Project.

3. G. Cross-Connect Panel: Modular array of IDC terminal blocks arranged to terminate building cables and permit interconnection between cables.
4. Number of Terminals per Field: One for each conductor in assigned cables plus 25 percent spare.

H. Patch Panel: Comply with TIA/EIA-568-C, meeting or exceeding cable performance. Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
1. Number of Jacks per Field: One for each four-pair conductor group of indicated cables, plus spares and blank positions adequate to satisfy specified expansion criteria.

I. Jacks and Jack Assemblies: Modular, color-coded, RJ-45 receptacle units with integral IDC-type terminals. Use non-keyed jacks for data service.

J. Patch Cords: Factory-made, four-pair cables in 48-inch lengths; terminated with RJ-45 plug at each end. Use non-keyed plugs for data service.

2.14 FIBER-OPTIC CABLING

A. Cable, Terminal, and Connector Product Manufacturers:
1. CommScope Properties, LLC.
2. Corning Cable Systems.
3. General Cable Technologies Corporation.
4. Mohawk/CDT; a division of Cable Design Technologies.
5. Panduit Corp.

B. Fiber-Optic Cable: 50/125-micrometer, multimode optical fiber.

C. Building Service Fiber Cable: 24 fibers.
1. Comply with TIA/EIA-492AAAA, tight buffer.
2. NFPA 70, Type OFN complying with UL 1666.
3. Maximum Attenuation: 3 dB/km at 850 nm; 1 dB/km at 1300 nm.
4. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
5. Cable Jacket Color: Orange.

D. Backbone Fiber Cable: Six fibers.
1. Comply with TIA/EIA-492AAAA, tight buffer.
2. NFPA 70, Types OFN and OFNP.
3. Maximum Attenuation: 3 dB/km at 850 nm; 1.0 dB/km at 1300 nm.
4. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
5. Cable Jacket Color: Orange.

E. Cross-Connect and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.
1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to satisfy specified expansion criteria.

F. Patch Cords: Factory-made, dual fiber cables in 36-inch lengths.

G. Cable Connecting Hardware:
1. Comply with TIA/EIA-568-C.
2. Quick-connect, simplex- and duplex-Type SC couplers. Insertion loss not more than 0.7 dB.
3. Type SFF connectors may be used in termination racks, panels, and equipment packages.

2.15 COAXIAL CABLE

A. Manufacturers:
   1. Alpha Wire Company.
   2. B & L Coaxial Connections Ltd..
   3. Belden Inc.; Electronics Division.
   4. Coleman Cable.
   5. CommScope Properties, LLC.
   6. Helix/HiTemp Cables, Inc.
   7. JSC Wire & Cable.
   8. West Penn Wire/CDT; a division of Cable Design Technologies.

B. Cable Characteristics: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz, and shall be listed to comply with NFPA 70, Articles 810 and 820.

C. RG-11/U: No. 14 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid. Jacketed with sunlight-resistant black PVC or PE. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C; NFPA 70, Type CATV.

D. RG-6/U: No. 16 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation. Double shielded with 100 percent aluminum-foil shield and 60 percent aluminum braid. Jacketed with black PVC or PE. Suitable for indoor installations; NFPA 70, Type CATV or CM.

E. Coaxial-Cable Connectors: Type BNC, 75 ohms. Of three-piece construction, consisting of a crimp-type center tit, sleeve, and main body.

2.16 WORKSTATION OUTLETS

A. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, modular, RJ-45. Comply with TIA/EIA-568-C.

B. Workstation Outlets: Dual jack-connector assemblies mounted in single or multigang faceplate.
   1. Faceplate: High-impact plastic; color as selected by Architect.
   2. Mounting: Flush, unless otherwise indicated.
   3. Legend: Machine-printed, adhesive tape label identifying the circuit.

2.17 BACKBOARDS

A. A-C, void-free plywood, 84 inches high and 3/4-inch thick, fire rated.

2.18 GROUNDING AND BONDING

A. Materials: Comply with NFPA 70, TIA/EIA-607, and UL 467.

2.19 IDENTIFICATION PRODUCTS

A. Manufacturers, substitutions allowed if approved equal or better

1. Brady Worldwide, Inc.
2. HellermannTyton.
3. Kroy LLC.
4. Panduit Corp.

B. Comply with TIA/EIA-606-A and with applicable requirements in Division 16 Section "Electrical Identification."

C. Cable Labels: Self-adhesive vinyl or vinyl-cloth wraparound tape markers, machine printed with alphanumeric cable designations.

D. Computer-based cable management system, with integrated database and graphic capabilities.

1. Document physical characteristics by recording the network, TIA/EIA details, and connections between equipment and cable.
2. Information shall be presented in database view, schematic plans, or technical drawings. AutoCAD drawing software shall be used as drawing and schematic plans software.
3. System shall interface with the following testing and recording devices:
   a. Direct upload tests from circuit testing instrument into the PC.
   b. Direct download circuit labeling into labeling printer.

2.20 SOURCE QUALITY CONTROL

A. Coaxial Cable: Each cable spool sweep tested at the factory before shipping at frequencies from 5 MHz to 1 GHz. Sweep test shall test frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through specified frequency range and graphing the results.

B. Fiber-Optic Cable: Each cable spool tested at factory before shipping at 850 and 1300 nm. Test and inspect all equipment according to BICSI and North Carolina STS 1000 Guidelines.

C. UTP Cable Verification of Performance: Test every cable package or reel at factory to verify that cable complies with TIA/EIA-568-C requirements.

3.0 EXECUTION

3.01 INSTALLATION STANDARDS

A. Comply with BICSI TCI, TIA/EIA-568-C and TIA/EIA-569-A.

3.02 EXAMINATION

A. Examine pathway elements intended for cables.
   1. Verify proposed routes of pathways. Check raceways, cable trays, and other elements for compliance with space allocations, clearances, installation tolerances, hazards to cable installation, and other conditions affecting installation.
   2. Verify that cabling can be installed complying with EMI clearance requirements.

B. Prepare wall penetrations and verify that penetrations of rated fire walls are made using products labeled for type of wall penetrated.
   1. Identify plan to support cables and raceways in suspended ceilings. Verify weight of individual types and sizes of cables. Verify that load capacity of cable support structures is adequate for each pathway.

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

3.03 APPLICATION OF MEDIA

A. Backbone Cable for Data Service: Use fiber-optic cable for runs between equipment rooms and wiring closets and for runs between wiring closets.
B. Backbone Cable for Voice Service: Use UTP Category 3 cable for runs between equipment rooms and wiring closets and for runs between wiring closets.
C. Horizontal Cable for Data Service: Use UTP Category 6 cable for runs between wiring closets and workstation outlets.
D. Horizontal Cable for Voice Service: Use UTP Category 6 cable for runs between wiring closets and workstation outlets.

3.04 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install cables in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces. Cable trays are specified in Division 16 Section "Cable Trays." Raceways and boxes are specified in Division 16 Section "Raceways and Boxes."

C. Cable Installation:

1. Install exposed cables within Telecom Rooms parallel and perpendicular to surfaces or exposed structural members and follow surface contours where possible.
2. Make splices, taps, and terminations only at indicated outlets, terminals, and cross-connect and patch panels.
3. Pulling Cable: Do not exceed manufacturer's written recommended pulling tensions. 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.
4. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
5. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals within Telecom Rooms.
6. Install UTP cables using techniques, practices, and methods that are consistent with Category 6 rating of components and that ensure Category 6 performance of completed and linked signal paths, end to end.
   a. Do not untwist more than 1/4 inch of Categories 6 cables at connector terminations.
7. Outdoor Coaxial Cable:
   a. Outdoor connections shall be installed in enclosures complying with NEMA 250, Type 4X. Connectors shall be corrosion resistant with properly designed O-rings to keep out moisture.
   b. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches.

D. Wiring within Wiring Closets and Enclosures:

1. Install plywood backboards on walls of equipment rooms and wiring closets from floor to ceiling.
2. Mount patch panels, terminal strips, and other connecting hardware on backboards, wall-mounted racks, floor-mounted racks, and cabinets as shown on drawings.
3. Group connecting hardware for cables into separate logical fields.
4. Train conductors to terminal points with no excess.
5. Use lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

E. Separation from EMI Sources: Comply with BICSI TDM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment. Comply with the following minimum separation distances from possible sources of EMI:

1. Separation between unshielded power lines or electrical equipment in proximity to open cables or cables in nonmetallic raceways is as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: 5 inches.
   b. Electrical Equipment Rating between 2 and 5 kVA: 12 inches.
   c. Electrical Equipment Rating More Than 5 kVA: 24 inches.
2. Separation between unshielded power lines or electrical equipment in proximity to cables in grounded metallic raceways is as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: 2-1/2 inches.
   b. Electrical Equipment Rating between 2 and 5 kVA: 6 inches.
   c. Electrical Equipment Rating More Than 5 kVA: 12 inches.
3. Separation between power lines and electrical equipment located in grounded metallic conduits or enclosures in proximity to cables in grounded metallic raceways is as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
   b. Electrical Equipment Rating between 2 and 5 kVA: 3 inches.
   c. Electrical Equipment Rating More Than 5 kVA: 6 inches.
4. Electrical Motors and Transformers, 5 kVA or HP and Larger: 48 inches.
5. Fluorescent Fixtures: 5 inches.

F. Conduit:

1. Comply with TIA/EIA-569-A for maximum length of conduit and bends between pull points, and for pull-box sizing.
2. Use manufactured conduit sweeps and long-radius ells whenever possible.
3. In telecommunications rooms, position conduit ends adjacent to a corner on backboard (in case of a single piece of plywood) or in the corner of room (where multiple sheets of plywood are installed around perimeter walls of room). Use cable trays to route cables if conduits cannot be located in these positions. Secure conduits to backboard when entering room from overhead. Extend conduits 1 to 3 inches in finished floor.

G. Backboards: Install plywood with 84-inch dimension from floor up toward ceiling. Butt adjacent sheets tightly, and form smooth gap-free corners.

H. Telecommunications cabling and pathway systems, including the horizontal and backbone cable, pathway systems, telecommunications outlet/connector assemblies, and associated hardware shall be installed in accordance with EIA/TIA-568-C, EIA/TIA-569-A, NFPA 70, and UL standards as applicable. Cabling shall be connected in a star topology network. Metal raceway bases, covers, and dividers shall be bonded and grounded in accordance with EIA/TIA-607. Telecommunications cabling and pathways with copper media shall be installed in accordance with the following criteria to avoid potential electromagnetic interference between power and telecommunications equipment. The interference ceiling shall not exceed 3.0 volts per meter measured over the usable bandwidth of the telecommunications cabling. Pathways shall be installed in accordance with the following minimum clearance distances of 4 feet from motors, generators, frequency converters, transformers, or uninterruptible power system, 12 in from power conduits and cable systems, 5 inches from fluorescent or high frequency lighting system fixtures.

I. Cabling

Install Category 3 UTP, Category 6 UTP, and optical fiber telecommunications cabling and pathway system as detailed in EIA/TIA-568-CB. Screw terminals shall not be used except where specifically indicated on plans. Use an approved insulation displacement connection (IDC) tool kit for copper cable terminations. Do not untwist Category 6 UTP cables more than one half inch from the point of termination to maintain cable geometry. Provide service loop on each end of the cable, 10 ft. in the telecommunications closet, [3.3 ft in the work area outlet for optical fiber and] 12 inches for UTP. Do not exceed manufacturers' cable pull tensions for copper and optical fiber cables. Provide a device to monitor cable pull tensions. Do not exceed 25 pounds pull tension for four pair copper cables. Do not chafe or damage outer jacket materials. Use only lubricants approved by cable manufacturer. Do not over cinch cables, or crush cables with staples. For UTP cable bend radii shall not be less than four times the cable diameter.

J. Open Cable

1. Use only where specifically indicated on plans for use in cable trays (in equipment and telecommunications rooms only). Comply with EIA/TIA-568-C. Do not exceed cable pull tensions recommended by the manufacturer.

2. Plenum cable shall be used where open cables are routed through plenum areas. Plenum cables shall comply with flammability plenum requirements of NFPA 70 and shall comply with UL 910.

K. Backbone Cable

1. Optical fiber Backbone Cable. Install backbone optical fiber in indicated pathways. Do not exceed manufacturer's recommended bending radii and pull tension.
2. Prepare cable for pulling by cutting outer jacket 10 inches leaving strength members together and attach to pulling eye.

L. Horizontal Cabling

1. All telecommunications workstation cabling will be installed in minimum 1" conduit homeruns continuous from workstation to cable tray room.

M. Pathway Installations

1. Comply with EIA/TIA-569-A. Conceal conduit under floor slabs and within finished walls, ceilings, and floors. Keep conduit minimum 6 inches away from parallel runs of electrical power equipment, flues, steam, and hot water pipes.
2. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit is visible after completion of project. Run conduits in crawl spaces and under floor slabs as if exposed.
3. Install no more than two 90 degree bends for a single horizontal cable run.

N. Conduit Installed Under Floor Slabs

1. Conduits shall be 1" minimum. Conduit shall be located a minimum of 6 inches below the vapor barrier. Seal around conduits at penetrations through vapor barrier.

O. Service Entrance Conduit, Underground

1. PVC Type EPC-40. Underground portion shall be encased in minimum of 3 inches of concrete extending from the building entrance to 5 feet out from the building and shall be a minimum of 24 inches below slab or grade.

P. Cable Tray Installation

1. Install cable tray components in accordance with EIA/TIA-569-A. Only CMP and OFNP type cable shall be installed in a plenum.

Q. Work Area Outlets

1. Terminate UTP cable in accordance with EIA/TIA-568-C and wiring configuration as specified.

R. Telecommunications Closet Termination

1. Install termination hardware required for Category 6 and Optical fiber system. An insulation displacement tool shall be used for terminating copper cable to insulation displacement connectors.

S. Labeling

1. Each work area is labeled with a unique identifying number. A consistent labeling and numbering scheme shall be used. The labeling shall be clearly legible on the outlet face and the termination end. The numbering plan should identify the source and destination of the cable for horizontal runs.
2. A sample numbering plan is: 208A-A1/241B
   a. Where 208 is the telecommunications closet room #:
   b. "A" is the patch panel identification,
   c. "A1" is the "A" Block and the first position,
   d. "241" is the workstation room #,
   e. and "B" is the workspace of the user in room 241.

T. Horizontal cable shall be labeled at the workstation end and the cross-connect end. Backbone cables (whether riser or horizontal) shall have an identifying number that is labeled at each end. Labels shall be the same color on each end. Performance documentation must use the same labeling scheme.

U. Color Coding

TERMINATION TYPE	COLOR	COMMENTS
Demarcation Point	Orange	Central Office Terminations
Network Connection Circuits	Green	Network Connections or auxiliary circuits
Common Equipment	Purple	Used for all major switching PBX, host, LANs & data terminations, Muxes
First level Backbone	White	Main cross-connect to intermediate cross-connect
`	Gray	Intermediate cross-connect to telecommunications closet
Station	Blue	Horizontal cable terminations
Interbuilding	Brown	Campus cable terminations
Key Systems	Red	Key Telephone Systems
Miscellaneous	Yellow	Auxiliary maintenance alarms

V. Equipment Support Frames

1. Install in accordance with EIA/TIA-569-A.
2. Racks, floor mounted modular type. Permanently anchor rack to the floor per manufacturer's recommendations.

W. Electrical Penetrations

1. Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceiling in accordance with UL Firestopping details.

X. Grounding and Bonding

1. In accordance with EIA/TIA-607, and NFPA 70.

3.05 GROUNDING

A. Comply with Division 16 Section "Grounding and Bonding" and with TIA/EIA 607.
B. Grounding Points:
1. Locate grounding terminals in each equipment room, wiring closet, rack, and cabinet.
2. Telecommunications Groundign Bushbars: Mount on wall of telecommunications entrance facility, equipment room, and closet with standoff insulators.
C. Bonding Conductors:
1. Extend from telecommunications entrance facility to electrical entrance facility and connect to grounding electrode.
2. Where a panelboard for telecommunications is located in same room or space as a grounding busbar, bond to equipment ground bus of electrical panelboard.
3. Extend from telecommunications entrance facility to grounding busbars.
4. Extend from grounding busbars to ground terminals in equipment racks and cabinets.

5. Extend from grounding busbars to building metal frame within room, or to metal frame external to room but readily accessible.

D. Special Requirements:
1. Bonding conductors shall be insulated copper, No. 6 AWG minimum.
2. Install only in nonmetallic conduit, unless specifically required for protection of conductor. Metallic conduit, if used, shall be RMC. For RMC that exceeds 36 inches in length, conductors shall be bonded at each end of conduit.
3. Bonding conductors shall be installed without splices unless approved by Owner because of special circumstances. Where splices are necessary, they shall be accessible and shall be located in telecommunications spaces. Splices shall be by irreversible compression connectors or by exothermic welding.

3.06 IDENTIFICATION

A. In addition to requirements in this Article, comply with TIA/EIA -606-A and with applicable requirements in Division 16 Section “Electrical Identification”.

1. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.

B. Using cable and asset management software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique alphanumeric designation for each cable, and label cable, jacks, connectors, and terminals to which it connects with same designation. Use logical and systematic designations for facility’s architectural arrangement. At completion, cable and asset management software shall reflect as-built conditions.

C. Use logical and systematic designations for facility's architectural arrangement and nomenclature, and a consistent color-coded identification of individual conductors.

D. Cable and Wire Identification
1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
4. Label each terminal strip and screw terminal in each cabinet, rack or panel
   a. All wiring conductors connected to terminal strips shall be individually numbered, and each cable or wiring group being exteneded from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
   b. Label each unit and field within distribution racks and frames
5. Within Connector Fields in Equipment Rooms and Wiring Closets: Label each connecand each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
6. At Workstations: Attach label to device plate.

E. Cable Schedule: Post in prominent location in each equipment room and wiring closet. incoming and outgoing cables and their designations, origins, and destinations. Protect rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

F. Cabling Administration Drawings: Show building floor plans with cable administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner.

3.07 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Category 6 UTP Cabling tests:
   1. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-C. Perform tests with a tester that complies with performance requirements in Annex I, complying with measurement accuracy specified in Annex H. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
   2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
   3. Wire-map test that reports open circuits, short circuits, crossed pairs, reversed pairs, splpairs, and improper terminations.
   4. Channel and permanent link tests for cable lenths, insertion loss, near-end crosstalk loss, power sum near-end crosstalk loss, equal-level far-end crosstalk loss, power sum equal-level far-end crosstalk, return loss, propagation delay, and delay skew. Performance shall comply with minimum criteria in TIA/EIA-568-C.

C. Fiber-Optic Cable Tests:
   1. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-C. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
   2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
   3. Link End-to-End Attenuation Tests:
      a. Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
      b. Attenuation test results for horizontal links shall be less than 2.0dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-C.

D. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

E. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

F. Retest and inspect cabling to determine compliance of replaced or additional work with specified requirements.

3.08 DEMONSTRATION

A. Train Owner's maintenance personnel in cable-plant management operations, including changing signal pathways for different workstations, rerouting signals in failed cables, and keeping records of cabling assignments with revisions when extending wiring to establish new workstation outlets. Refer to Division 1 Section “Demonstration and Training”.

3.09 TESTING

A. Telecommunications Cabling Testing

B. UTP Testing

C. All cable pairs must be tested for the following conditions:
1. Polarity
2. Reversal of pairs
3. Wire transpositions
4. Continuity
5. Opens
6. Shorts
7. AC and DC foreign voltages
8. Level 5 NEXT End to End from Fraceplte through 110 connecting block and/or patch panel and jumper.
9. TIA/EIA-568-C wiring discrepancies

D. All test data will be documented and provided to the using agency at the time of acceptance.

E. Fiber Optic Testing

3.10 SYSTEM TESTING

A. Upon completion of the passive optical cable syste, the system must be tested to ensure compliance with the design and link loss specifications. The single most important test is end-to-end attenuation test that measures the optical power loss between cable termination points. The attenuation of a system at one wavelength is not necessarily related to the attenuation at the other, except for the short links such as horizontal cabling. The best way to verify the cabling meets the loss limit is to measure each segment between patch panels. Because of the stress and bending that cables undergo during installation, measurement of the attenuation of each link with connectors in place is required after installation.

B. The tests include:

1. Power meter tests – For building risers, power meter tests are required. Disregard optical time-domain reflectometer (OTDR) testing runs for less than 2 kilometers

testing of end-to-end attenuation on each fiber span at both operational; wavelengths.

2. 850/1300 nm (nanometers) wavelength for multimode fiber
3. 1310 nm wavelength for single mode fiber

C. Testing in one direction is required. Test results should be retained for inclusion into the documentation package.

D. Optical Time Domain Reflectometer (OTDR) Signature Traces of each terminated fiber should be recorded at 850 nm and 1310nm for fiber continuity purposed. OTDR testing is mandatory for runs longer than 2 kilometers.

E. A Final Report should be compiled that records system configuration, fiber labels, cable routes and "as built" details, Loss measurement and OTDR traces should be included.

F. Inspection

1. Visually inspect cabling jacket materials for UL or third party certification markings. Visually inspect UTP and optical fiber jacket materials for UL or third party certification markings. Inspect cabling terminations in telecommunications rooms and at workstations to confirm color code for tip an dring assignments, and inspect cabling connections to confirm compliance with EIA/TIA-568-C. Visually confirm Category marking of outlets, wallplates, outlet/connectors, and patch panels.

G. Verification Tests

1. During installation of cabling systems, perform optical fiber end to end attenuation tests using an optical time domain reflectometer (OTDR) and manufacturer's recommended test procedures. Perform tests in accordance with EIA/TIA-526-14, Method B for horizontal, multimode optical fiber and EIA/TIA-526-7, Method B for backbone, single mode optical fiber. Perform verification acceptance tests and factory reel tests.

H. Final Verification Tests

1. After the complete telecommunications cabling and workstation outlet/ connectors are installed, perform verification tests for UTP and optical fiber systems. These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Do off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and DSN telephone call.

END OF SECTION 16715

SECTION 16720
SECURITY SYSTEMS

1.00 GENERAL

1.01 GENERAL DESCRIPTION

A. The security systems to be proposed to the Owner shall be capable of integrating, interfacing and/or operating with other systems.

B. This section covers the provision of the security systems including all items and subsystems shown on drawings or otherwise required by this specification.
   1. Security systems computer hardware, software, and control panels for access control and alarm management
   2. Card readers and other security input/output devices for access control and alarm monitoring of secured areas
   3. Photo Identification Production
   4. Interface with Vehicle Access and/or Parking Gate Operators
   5. Video Surveillance System
   6. Communication Equipment and Network Hardware
   7. Fiber Optic Transmission Equipment, Fiber Optic Cable, and other required cable
   8. Security Console and/or Racking Equipment

1.02 SCOPE OF WORK

A. The Security Contractor shall include all necessary wiring, cabling, labor, tools, equipment, and ancillary materials required to furnish and install a complete and operational security system.

B. Requirements are indicated elsewhere in this specification for work including, but not limited to:
   1. Conduit, 220 VAC power extensions, and other electrical work shall be furnished and installed by the Contractor. Security Contractor shall coordinate with other trades to ensure the needed infrastructure is in place.
   2. Electronic door hardware, electronic latch retraction egress devices and any associated power supplies at card reader doors shall be furnished and installed by the Door Contractor.
   3. The Contractor shall provide local area network (LAN) connections as shown on the attached drawings for security systems.
   4. The Security Contractor shall coordinate with the Owner for external local area network (LAN) connections as shown on the attached drawings for security systems.

C. The security systems shall provide management, control, and monitoring of card access and alarms.

D. The extent of security systems work is defined to include but not limited to the following:
   1. The security systems database and application host server shall be installed in the Main Server / Data Center, that is shown in the Drawings. The space requirements and sizing for the room shall be confirmed during Design.
   2. The database will be capable of being partitioned to provide for full control by the Owner and local programming and control by the Owner authorized personnel for their defined spaces.
   3. Operator workstations (thick clients) shall be installed in the Front Guard Desk, the NIH Director's Office, and the Containment Area security control room.

4. Browser based operator workstation (thin clients) license for up to five (5) users

E. Installing the security systems and bringing it to operational status for acceptance shall include but not be limited to the following:
1. Determine hardware, software, and operations requirements for implementation.
2. Install security systems hardware and software.
3. Set up and configure communications between the host server, operator workstations, and control panels.
4. Set up and configure security systems application, database, and partitions.
5. Test security systems operations based on a point-by-point walkthrough inspection.
6. Perform end-user training.

1.03 SUBMITTALS

A. Submittals shall ensure that all parties involved can determine that the proposals meet the security systems requirements as desired.

B. Executive Summary System Description: Descriptive statement of the system function and single-line block diagram to show how all related equipment shall interface and operate as complete security systems.

C. Value engineering is encouraged; however any value engineering must be equal to the system specified. The security contractor must make every attempt to meet the original specification or show exceptions with documentation of substitutions supporting any alternate equipment or systems.

D. Bid Pricing shall be submitted in the following forms:
1. Parts list (quantities, manufacturer and part numbers) for all major components.
2. Total price for the entire project.

E. Changes orders, moves, additions: Shall be submitted per general conditions of the Contract, Article 19.

F. Maintenance Agreements and Extended Warranty: refer to Section 1.8 of this document.

G. Product Data: Manufacturer's technical data sheets on each product proposed.

H. Shop Drawings: Provide complete shop drawings that include the following:
1. Point-to-Point diagram of all security system device locations on architectural floor plans. No other system(s) shall be included on these plans.
2. Detailed schematic wiring diagrams for all system devices. Wiring information shall include cable type, conductor routings, quantities, and connection details at devices.

I. Manuals: Manufacturer’s user’s manuals for operations, administration, installation, and maintenance.

J. Software: one set of fully functional security systems software in manufacturer’s original media packaging, temporarily licensed for a 30-day evaluation period.

K. Contract Close-Out Submittals:
1. Training Course Materials: Stated elsewhere in this document.

2. Commissioning Test Plan and Check-Off List: Stated elsewhere in this document.

L. As-Built Drawings: During system installation, the Security Contractor shall maintain a separate hard copy set of drawings, elementary diagrams, and wiring diagrams of the security systems to be used for record drawings. This set shall be kept up to date, reflecting all changes and additions made to the security systems. Copies of the final as-built drawings shall be provided to the owner in DWG or DXF format using the latest version of AutoCAD.

1.04 QUALIFICATIONS

A. The Security Contractor shall be regularly engaged in providing security equipment and security related services and shall have been engaged in such work for a period of not less than five (5) years prior to bid submittal.

B. The Security Contractor shall, at the time of the bid, be licensed to perform security work. Security Contractors who have security licenses or permits pending shall not be considered acceptable for bidding on this project.

C. All personnel employed by the Security Contractor shall be registered with the appropriate Philippine licensing board as provided for by professional codes and regulations.

D. Each Security Contractor submitting a bid for this project shall include with his bid a copy of his current alarm system or low voltage license.

E. The Security Contractor shall, at the time of the bid, be licensed as an Electrical Contractor in the SP-LV, Limited, Intermediate, or Unlimited classification.

F. Each Security Contractor submitting a bid for this project shall include with his bid a copy of his current Electrical Contractor license as issued by the professional board.

G. The Security Contractor shall, under provisions of Division 1, provide satisfactory evidence of liability insurance and Worker's Compensation coverage for employees as required by law.

H. The Security Contractor shall provide the name and location of three (3) similar projects that would be available for inspection by the Owner or his representative in order to verify the competency of the Security Contractor to perform within the scope of this project.

1.05 WARRANTY AND MAINTENANCE

A. The security systems software, hardware, and installation shall be warranted against defects and workmanship for a period not less than 12 months from the date of final acceptance by the owner. The warranty shall cover all parts and labor, after final acceptance by Owner, per general conditions of the Contract, Article 42.

B. The Security Contractor shall guarantee that the security systems application software/firmware remains current at all times with the latest enhancements; supported by the security systems manufacturer with unlimited remote dial-in diagnostics capability and technical phone support.

C. The Security Contractor shall perform manufacturer’s recommended preventative maintenance on all applicable components and/or devices during the warranty period.

D. The Security Contractor shall be the primary contact and respondent for all service and support; officially recognized and backed by the security systems manufacturer.

E. Extended and/or out of warranty terms at reasonable and customary rates shall be available from the Security Contractor.

F. The Security Contractor shall provide a separate proposal to the owner, after contract award, for an extended warranty and maintenance service contract.

1. Length of contract 5 years, to begin after the first year warranty period. The period covered shall be the subsequent years two through six.
2. The service and maintenance contract shall consist of:
   a. A minimum of two (2) quarterly, on-site inspections or as required by manufacturers specifications, whichever is greater. Each inspection to include but not be limited to:
      1) Corrective maintenance and adjustments to restore the system to original operating condition.
      2) All required parts except those that are subject to normal wear or are expendable.
      3) All labor, travel and personnel expense.
   b. On-call Service
      1) Submit separate labor costs for “on call” service to include but not be limited to:
         a) In shop service – including labor rates, transportation and shipping expenses.
         b) Non-emergency service (next business day).
         c) Emergency service (4-hour response, 24/7/365).

1.06 DOCUMENT PREPARATION AND CONTROL

A. All design guides, design development documents, construction drawings and record drawings are extremely confidential. Access to these documents shall be restricted to authorized personnel and the Security Contractor. Parties receiving these documents shall take every reasonable precaution to protect these documents from unauthorized access and must sign and non-disclosure agreement.

B. Drawings and documents relating to this project which are no longer required shall be disposed of by complete destruction.

C. Distribution of any section of these guidelines to other persons or companies shall not be made without prior written approval of the Owner or their representative.

1.07 DEFINITIONS

A. 24-Hour Zone is a zone that is always active.

B. Access Control is the method of regulating or restricting personnel movement in an area to those personnel previously authorized to be there.

C. Access Control Module (ACM) is the termination point for alarm monitoring and low-voltage power supply cables servicing the building or major area of the building.

D. Accessible components or devices are those which are readily available to unauthorized personnel and which may be vulnerable to tampering or compromise. Components or devices are considered accessible if they are:

1. Located lower than ten feet from the floor on a finished or unfinished wall inside a building.
2. Mounted to the finished surface of a suspended ceiling inside a building.
3. Mounted on the exterior surface of a building.
4. Mounted to any surface or structure outside a building.
5. Note: Components or devices that are located completely inside another locked enclosure or which are normally concealed by building structure are generally considered to be inaccessible.

E. AHJ, or Authorities Having Jurisdiction, is a generic term used for a person or organization that has some form of joint sovereignty. This term is commonly used to refer to local governments, local/state Fire Marshals, or Building Inspectors

F. Alarm Point is a connection to an alarm input on the alarm control panel. Alarm points are always normally-closed contact devices (contacts open on alarm). Each alarm point has a unique identity on the panel and may be custom programmed.

G. Anti-Passback is a system designed to prevent or discourage a user from using a card to gain entry and then pass the same card back to another to allow them entry.

H. Arm (also known as Set or Turn On) is a procedure followed by a system user or a remote facility to turn on an alarm system so the system is able to detect the conditions it is designed to protect against.

I. Card Access is a method used to provide access control at designated doors.

J. Central Station (CS) is a monitoring facility that is listed by, and operating according to, standards established by UL and or FMRC, and providing installation, maintenance, and support services required for central station alarm systems by UL or FMRC, under the management and responsibility of the monitoring facility.

K. Close is the act of arming a security system.

L. Commercial Power Outage refers to the condition where a reduction of available commercially provided voltage at the load does not permit the equipment to function as designed

M. Contact refers to either a magnetic switch assembly used to detect door status or to a relay output from alarm initiation devices, security control panels or fire alarm control panels.

N. Controllers, access control and alarm inputs, are microprocessor-based, digital technology and distributed intelligence architecture. Controllers collect data from the field devices and provide the information to the file server. Controllers operate independently of one another with all database information stored at the control panel level.

O. Control Panel is the part of a security system that handles control and communication and to which initiating devices are connected. The Control Panel will seize the connected telephone line, dial a predesignated number to connect to the Central Monitoring Station, and transmit signals indicating a status change of the initiating device.

P. Closed Circuit, or CCTV, means that the camera image is displayed via a complete or closed path from the camera to a specific display and/or recording device.

Q. Delayed Zone is a zone configured to provide a time delay, when activated, before an alarm is generated.

R. Disarm (also known as Closing or Turning Off) is a procedure followed by a system user to turn off an alarm system so that no alarm signals will be transmitted to the monitoring facility, nor will any audible or visual signal be generated at the alarm system location. If a system is disarmed within a pre-determined time period after a sensor has been triggered (typically referred to as a delay period), it may be possible to abort the alarm and prevent it from being transmitted to the monitoring facility.

S. Door Open Time is the time allowed for a controlled door to remain open after a valid entry. At the expiration of this time, the system records a transaction that may be defined as an alarm. If the alarm bypass relay were used, it would also de-energize at this time.

T. Drop # refers to the room(s) or location(s) housing the RTU, FIP, and associated equipment serving the building or a major area of the building. The security head end equipment generally requires ten (10) feet of unobstructed wall space and a minimum five (5) foot clearance for equipment access. The head end may share space with telecommunications equipment if necessary. The room containing the security head end is always protected with a contact on all doors and accessible openings with some cases having a motion detector or glass break detector as an additional layer detection.

U. Duress is the presence of one or more persons trying to force an individual to enter a facility against the individual's will.

V. Electronic Digital Locks is a method used to provide access control at some doors. Owner uses a stand-alone, fully keypad programmable type for all applications. The lever set complies with the 1992 Americans with Disability Act and is equipped with key override.

W. Electric Strike is electrical device that permits releasing of the door from the strike side of the door by remote control.

X. Embarrassment Alarm is a local door annunciation assembly used to control the use of certain doors by authorized or unauthorized personnel. This assembly includes a local sounder that can be bypassed through the system software.

Y. Emergency Power refers to electrical supply circuits that continue to provide power in the event of a commercial power outage. Emergency power may be supplied by generator or UPS and may be momentarily interrupted during the transition from commercial power to emergency power.

Z. Entry/Exit Zone is a delayed zone on the protected premises. These zones are usually associated with perimeter devices although interior devices or zones may be “followers” to the perimeter devices.

AA. Fail-Safe is when, on loss of power, access points automatically electronically unlock, thereby allowing free access. The card access system would automatically be notified of a device malfunction or loss of power. Power is applied constantly to the lock hence the door is unlocked when power is lost. Also known as “fail open”. In all cases free egress must be maintained. Doors using Fail Safe mode must be rated for Continuous Duty.

BB. Fail Secure is when, on loss of power, access points remain mechanically locked. The card access system would automatically be notified of a device malfunction or loss of power. Provision should be made to allow for manual unlocking of the door hardware by using a key. Power is sent to the lock to unlock and in the event of power failure the door remains locked and requires a manual unlock (override) until the power is restored. In all cases free egress must be maintained.

CC. FIP is a Field Interface Panel that is the termination point (usually a locked enclosure) for copper and fiber optic cable entering and/or leaving a facility. The FIP always requires a dedicated quad receptacle with 115 VAC emergency power, mounted inside the enclosure. The FIP must be tampered (see definition below).

DD. Follower Zone is a non entry/exit zone, typically an interior zone located on an entry/exit path and is treated as an entry/exit zone during an Entry or Exit delay time.

EE. Homerun cable and conduit must be separate from other cable and conduit runs for their entire length. Devices required being homerun to a FIP or RTU (see definitions) must use a separate conduit system and cable from each device back to the FIP or RTU. No splices of any kind are permitted in any cable used in a Security System.

FF. Inaccessible components or devices are those that are located completely inside another locked enclosure or which are normally concealed by building structure.

GG. Magnetic Lock is a locking device that consists of a metal plate that is fastened to the door and an electromagnet is attached to the door frame. When the electromagnet is energized, it holds the plate, and by extension, the door to which it is attached, together.

HH. Open is the act of disarming the intrusion system.

II. Partition is a defined area within the security system that can be armed or disarmed independent of the other areas, but is operated under a single system control. (Dedicated or shared user interfaces may be used to operate a system.)

JJ. Point is an electronically addressable sensor, sometimes used interchangeably with the term’s sensor or device.

KK. Protected indicates the area which requires the greater degree of security or the higher level of restriction. Details of door contacts and other security devices should always indicate which side is the protected side.

LL. Reader is the card access assembly that detects the presence of an access control card presented by an individual and transmits the card data to the associated card access controller.

MM. Request To Exit (REX) is a device that allows egress through an access control door without setting off an alarm by providing input to the access control system authorizing the egress.

NN. Strike is a plate mortised into or mounted on the doorjamb to accept and restrain a bolt when the door is closed. (Also known as a "keeper")

OO. Tampered indicates that the device or enclosure has been provided with a switch which reports to the Owner's Security System as an alarm point. Removal or opening of the component will immediately transmit an alarm to security personnel. All equipment enclosures must be tampered.

PP. Tamperproof refers to the use of screws or fasteners that cannot be removed with readily available hand tools.

QQ. Unprotected indicates the area which requires the lesser degree of security or the lower level of restriction. Details of door contacts and other security devices should always indicate which the unprotected side is.

RR. UPS Power refers to electrical supply circuits that continue to provide power in the event of a commercial power outage. UPS power differs from emergency power in that it is not momentarily interrupted during the transition from commercial power to emergency power.

SS. Zone is a dedicated input to the control panel containing one or more sensor devices which will trip that input upon activation of any one sensor device.

1.08 SITE VISIT

The Security Contractor is advised to visit the site to ascertain for himself the prevailing local conditions there at and to check the existing level of access and security at the NIH. Also, to investigate other pertinent things that may affect his work. It shall be presumed that he had done this before preparing his proposal and no subsequent claim on the ground of inadequate or inaccurate information will be entertained.

2.00 PRODUCTS

2.01 QUALITY ASSURANCE

Where specifications of any type of material or equipment are in question, such materials shall conform to the standard specifications set by the following:

A. U.S. UNDERWRITERS LABORATORIES
B. U.S. NATIONAL BOARD OF FIRE UNDERWRITERS
C. NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
D. INSULATED POWER CABLE
E. AMERICAN STANDARDS ASSOCIATION
F. BUREAU OF STANDARDS, DEPARTMENT OF TRADE
G. PHILIPPINE NATIONAL STANDARDS

2.02 CARD ACCESS CONTROL SYSTEM

A. The devices described herein are intended to provide a reference for the Card Access/Security System and are to be provided as described in the Contract Documents. The devices shall be housed in a secure location approved by the owner.

B. Certain devices described may not be applicable to all systems. All devices required to complete the installation may not be described but shall be provided as if specifically called for within the Specification. It is the responsibility of the Security Contractor to provide a complete working system.

C. All system components shall be approved for the function they will perform.

D. The system shall be of an open architecture design and shall support industry standard databases such as Sybase Adaptive Server Anywhere, Microsoft SQL Server, or MSDE.

E. A system server shall provide enterprise wide database services, system programming, system monitoring, administrative services, report, and proximity card generation.

F. A workstation computer shall provide interfacing and control of the local, site specific, Access Control Security System.

G. The System shall be of a distributed database design, using intelligent microprocessor panels, to make smart decisions at the door.

H. The system shall be capable of utilizing a true client server network configured to support the system database service, all panel services and user interfaces optimizing the users' options for system programming, event monitoring and record keeping.

I. The database service shall be ODBC compliant allowing the system to access an existing compatible ODBC compliant database as the system data source. A single system database shall maintain credential holder's records as well as access system information and programming parameters.

J. Provide servers and workstations that at least meet the minimum specifications as outlined by the manufacturer. If the system requires faster computers, it is the responsibility of the security contractor to provide computers that will perform as required and meet the manufacturers' requirements.

K. All security workstations shall have dual monitor cards and two (2) 19" to 21" flat screen displays.

L. Elevator Control

1. The system shall have the ability to provide elevator access control by (1) using a card reader to activate the elevator call button, (2) using a card reader in the cab to activate the correct floor selection button, or (3) a combination of both of these functions. The system shall have special field panels specifically designed to handle inputs and outputs used to interface with the elevator controls.
2. The panels specifically designed for elevator control shall support either a single elevator cab for up to 64 floors, or up to 4 elevator cabs for up to 16 floors each.

3. Each cardholder shall then have floor permissions assigned as part of the normal access rights. The system shall provide outputs to the elevator controls to uniquely verify which floors are authorized for each cardholder. The system shall be capable of tracking which floor was enabled or selected by that person.
4. Where destination elevators are used, coordinate with the elevator contractor for specific interfaces.

M. High Availability and Disaster Recovery

1. To provide greater client software availability, software shall support the ability so that in the event of a database server failure, client machines will quickly and without operator intervention, automatically connect to a standby server machine.
2. This configuration shall utilize the industry standard Microsoft clustering solution and allows an installation with a large number of client machines the ability to continue to operate without interruption while the cause of the main server failure is investigated.
3. The SMS product must be capable of supporting options for 99.99% and 99.999% availability.
4. The SMS product must support a disaster recovery solution using off-site database replication.

N. Operator Permissions

1. System operators shall be associated with a log in Name and Password. A system option will determine whether strong operator passwords will be used. The minimum definition of a strong password shall be a password that contains at least one upper case character, one lower case character, one numeral and one punctuation mark, with a minimum password length of six characters. Additionally the password cannot contain any full word of the operator's username.
2. The option to use a Secure Biometric or Smart card for system logon shall be provided. When used, this option will force the operator to present their Name, Password and Biometric or Smart card.
3. Operators shall be assigned to permission profiles. This will determine the functions that will be available to that operator when logged on to the system. Each operator is required to only see the functions for which he or she has access. The system shall support an option to hide Personal Identification Numbers of cardholders when an operator is viewing a record.
4. Card record data entry shall be divided into operator permission areas, allowing separate permission categories to be assigned for the viewing of personal data, ID badge printing and access right management.
5. For all operators, a means of re-arranging their Icon tool bar shall be provided to allow the most frequently used Icons to be repositioned by the operator.

O. Video Imaging and ID Badge Printing

1. The system shall incorporate video imaging as a fully integrated function to customize access control cards by printing an identity badge directly onto the card. The badge design and image capture capabilities shall combine with the latest technology card printers to allow the production of an ID badge pass for each card holder at the time of registration.
2. For each cardholder both a facial image and a signature shall be able to be captured or imported and stored as part of the card record. These images shall be captured from a standard CCTV camera connected to the computer via a Video Card supporting

DirectX 8 (or later) or MCI format, or imported if available as a bit map or JPEG file. The system shall use data compression techniques to ensure efficient use of the available hard disk space to maximize the number of images that can be stored on the hard disk.

3. Alternatively a signature may be imported from a signature capture terminal connected to the system via an RS 232 com port of the client PC local to where the card is being issued.
4. A comprehensive integrated badge design facility shall also be provided, allowing an unrestricted number of custom badge layouts to be defined then saved with a suitable description as a reference. This shall make full use of the card record details such as name, card number, and inactive date as well as allowing personal data to be included in the badge design. Company logos shall be imported as bit maps or JPEG images to provide a personalized corporate appearance to the card.
5. All elements incorporated into the design shall be able to be rotated.
6. Each badge design shall contain either a single sided design or a double-sided design. Each side of the card shall also be designated as being blank, or magnetic stripe side, or smart chip side, to ensure the designer is aware of the available space where printing may be incorporated for each card combination. The badge designer function shall be capable of supporting portrait, landscape, standard and custom-sized card designs.
7. When creating a new card record a badge preview screen shall also be included that displays the specific card's details on the selected badge design to allow confirmation prior to requesting the badge to be printed.
8. Each new cardholder record shall have the option to be flagged for future printing. Cards flagged in this manner shall be easily recalled at a later stage and processed for output to the printer in a single action. Selecting multiple cards for bulk printing shall also allow each card to be printed either with its specific badge design, as defined within each card's record, or alternatively printed with a selected common badge design. Encoding of magnetic stripe cards shall also be included as part of the bulk printing process.
9. The SMS shall support any manufacturer's ID badge printer with a Microsoft Windows 2000 or Windows XP (depending on the workstation configuration) compatible printer driver.
10. Each badge design shall include a default printer, validity period, and access rights.
11. The security contractor shall provide and install complete ID badge creation and printing as part of the base bid.
12. Video Verification
    a. The Video Imaging option shall also provide a monitoring screen that will automatically display the stored image for a card when used at a reader. This screen shall operate in conjunction with a live video input from a CCTV camera viewing the selected access point, allowing the operator to verify that each card offered is in fact being used by the person to whom it was issued.
    b. This screen shall also be frozen and printed to provide a hard copy evidence of any abuse observed by the operator. For high security access points, the system shall be configured to not grant access until the operator has verified the stored and live images are the same person, with the door release being controlled by the system operator.
13. Report Generation

a. Extensive history reporting shall be a standard integrated feature, and shall include the ability to review all system alarms, access control activity, and operator actions. These reports shall be made available for review via the operator's display screen, or to a printer, or to another disk media. Extensive sort parameters shall include by any of the "Personal Details" fields or Titles, for example by "Department", and only Names commencing with "SM*".

b. The system shall support generation of reports detailing the system operation. The following reports shall be available in the software:
   1) Cards on site
   2) Hours on site
   3) Cardholders with access to each door
   4) Access rights of each cardholder
   5) System Configuration
   6) Scheduled and Conditional Commands defined
   7) System operator transaction history

2.03 CARD READERS

A. Provide a contactless smart card reader that will read the secure sector of a smart card presented for access.

B. The reader shall have a minimum read range of one to three inches of a type technology system that complies with UL 294 standards and is certified as complying by Underwriters' Laboratories.

C. Shall be an indoor/outdoor wall switch or mullion mounted contactless smart card reader providing a Wiegand output.
   1. Shall mount in a door entry panel electrical box and shall be powered directly from the panel.
   2. The reader shall be sealed in a rugged, weatherized enclosure designed to withstand harsh environments as well as provide a high degree of vandal resistance when installed

2.04 ACCESS CARD REQUIREMENTS

A. Access cards shall be PVC multi-technology type cards.
   1. Shall be either ISO 14443 or ISO 15693.
   2. Shall contain a proximity chip that works with the current proximity card format in use at other State of North Carolina office facilities.
   3. Verify exact card requirements with Owner.

B. The cards shall be pre-fabricated, credit-card size, constructed of molded plastic. The card shall be capable of having multi-color custom graphics and permanently marked numbers printed directly onto both sides.

C. The card shall be made of robust ABS plastic to provide maximum protection for the circuitry inside and provide minimal flexing which could cause damage to the card. The user may specify codes or numbers and exact replacement of cards that may be have been lost, damaged or stolen shall be available upon request.

G. All cards shall be passive devices with no internal battery, but shall contain a semiconductor element that is energized when brought within the operating range of the reader causing transmission of the code from the card to the reader.

3.00 EXECUTION

3.01 DESIGN DEVELOPMENT

Final design for the security system in the NIH building shall be determined during preparation of construction documents. Requirements for utilities shall be coordinated with the architectural and engineering designers, contractor and the Owner.

3.02 CONSTRUCTION

Work shall be coordinated with that of other trades. All work shall be protected with temporary protection and shall be replaced if damaged prior to acceptance by the Owner.

3.03 INSTALLATION

Work shall be coordinated through the Owner's designated representative. Prior to Beneficial Occupancy of the building, installation of security systems may be requested to protect and safeguard laboratories that are significantly completed.

3.04 DOCUMENTATION

The Security Contractor shall provide electronic copies of drawings and manuals.

3.05 TESTING

A. Site tests shall be performed with a representative of Owner in attendance

B. The Security Contractor shall coordinate the scheduled time of testing and access to the site with Owner to minimize the disruption of the activities of the Owner or other contractors.

C. The Security Contractor shall provide all test equipment, tools, recorders, connectors, cables, and other devices required for the completion of systems tests.

D. The Security Contractor shall provide or coordinate the availability of ladders, lifts, scaffolding, or other equipment required to provide safe and ready access to all installed devices for the use of the Owner representative.

E. The Security Contractor shall provide two-way radios, telephones, cellular telephones, or other communications devices necessary to communicate with any remote facility monitoring the security systems during the testing.

F. The Security Contractor shall demonstrate to Owner that all sequences operate correctly and that all products, devices and system software operate as designed and specified.

G. Tests shall be performed on each major component of the Electronic Access Control system.

K. Sufficient replacement parts shall be available to allow for timely replacement of any parts that are found to be unsatisfactory in performance.

L. Alarm Inputs
1. All alarm points shall be tested back to the monitoring facility by activating the alarm devices to which they are attached. Activating or simulating an alarm condition at the control panel is not acceptable.
2. The proper programming of alarm points shall be verified and a hard copy of the signals provided by the monitoring facility (if monitored).
3. Magnetic switches and other similar alarm initiating devices shall be tested in the manner and method recommended by the manufacturer.

M. Card Access
1. All card readers shall be tested with cards previously loaded into the local controller database and with cards that have only been loaded into the system server files. Cards previously loaded into the local database should be validated and access granted within three seconds of presentation. Cards that have not been loaded into the local database should require no more than fifteen seconds from presentation to be validated through the server.
2. Card access doors shall be checked for proper operation of the electronic locking devices, including the internal monitor switch operation.
3. All associated tamper switches and trouble relays shall be tested back to the security console.
4. The proper programming of card readers shall be verified at the Security Console. Programming items to be verified for each reader shall include, but not be limited to, the following:
   a. Assignment of new inputs and outputs to the system.
   b. Necessary time and day interval programming.
   c. All control by event sequences to assure system operation is as specified.
   d. Selective logging and report programming.
   e. Access interval and access group programming for the card access system.
   f. Alarm message generation programming.
   g. Assignment of new card readers into the system

N. Electronic Locking Hardware
1. Locks shall be checked for proper alignment and bolt operation and full engagement of the strike plate.
2. Doors equipped with electric locks shall be checked for the proper operation of an automatic door closing device. When released, the doors shall close completely and re-latch automatically within the "door open time" programmed in the local controller.

3.06 TRAINING

A. The Security Contractor shall hold an eight (8) hour training session, for up to six (6) personnel at the job site at times mutually agreed upon with Owner.

B. Users of the Security Management System shall be thoroughly instructed verbally and in writing of the proper operation of all equipment and the procedures to be followed.

C. Time spent on field set-up, start-up and testing shall not be considered as training time.

3.07 ACCEPTANCE AND PERFORMANCE REQUIREMENTS

A. This system shall not be considered accepted until all punch list items have been corrected. Beneficial use of part or all of the system shall not be considered as acceptance.

B. The owner reserves the right to evaluate the installed system for a period of 30 days, subsequent to the satisfactory completion of the system acceptance tests, before final payment shall be made.

C. The Security Contractor shall complete the installation of all equipment in a reasonable and timely manner consistent with the Owner's construction schedule.

D. The Security Contractor shall provide properly skilled and factory trained personnel, the proper materials, and perform in a good workmanlike and timely manner satisfactory to the Owner.

E. The Security Contractor shall not hire any subcontractors for installation, maintenance, or service of the system without prior written approval by the Owner of such subcontractors for this work.

F. If the Security Contractor fails to make a good faith effort to complete the project in a timely manner, or attempts to block or delay installation and turnover of the specified system in any manner, then the Owner may, without prejudice to any other right or remedy it may have, terminate the contract and take possession of any materials, equipment, tools, and machinery thereon owned by the Security Contractor and may finish the services by whatever method the Owner may deem expedient.

G. If the Security Contractor fails to make prompt payment to subcontractors for materials or labor, or disregards laws, ordinances, rules, regulations, or orders of any public authority having jurisdiction, then the Owner may, without prejudice to any other right or remedy it may have, terminate the contract and take possession of any materials, equipment, tools, and machinery thereon owned by the Security Contractor and may finish the services by whatever method the Owner may deem expedient.

3.08 WARRANTY & MAINTENANCE

A. The Security Contractor shall guarantee all equipment, wiring, labor, and other components of this system to be free of defects in workmanship and material for one year or the manufacturer's warranty period, whichever is longer, from the date of acceptance by Owner.

B. Warranty service by the Security Contractor shall include four-hour emergency response service during normal contractor working hours and twelve-hour emergency response service after normal working hours, on weekends, and on holidays. Response time shall be measured from the time of Security Contractor notification to the arrival of service personnel at the affected site to initiate repairs. The Security Contractor shall provide a method of requesting emergency service after normal working hours, on weekends, and on holidays appropriate to the required response times.

C. Service requests are requests for work to repair or replace a system component or software application which has malfunctioned or been damaged. Service requests shall not include routine system additions, equipment relocations, or system upgrades.

D. The Security Contractor shall, after project completion, include the cost for a full-coverage service and maintenance contract for the second through sixth years following the initial warranty period. The service and maintenance contract shall be provided directly to the owner and provide for service and response times identified in Section 1. Owner shall be permitted to elect the service contract(s) any time prior to the expiration of the initial warranty period at the price submitted with the original bid.

E. If the extended warranty is executed by Owner, the labor rate and margin rate shall be the same as the initial bid for the project. Rate increases are allowed once per year due to equipment and labor cost increases. The owner must be notified in writing, thirty (30) prior to the increase going into effect. Cost increases cannot increase greater than the national Consumer Price Index.

END OF SECTION 16720

SECTION 16721
FIRE ALARM SYSTEM

1.00 GENERAL

1.01 SCOPE

The work includes providing code-compliant fire alarm systems for a mixed-use high-rise with total occupancy exceeding 1,000 people. The fire alarm shall address the needs of persons who may be vision and hearing impaired by providing strobe lighting and multi-address voice announcements alerting the occupants to exit the building.

The fire alarm system shall be connected to the elevators to automatically send elevators to the main level for speedy exit.

The work includes the furnishing, installation, commissioning and putting into operation and ready for use a non-coded Class A automatically activated presignal, general alarm, presignal, 2-wire supervised detection system. The fire alarm system shall consist of main control panel, manual stations with key switch, manual stations with key switch and vibrating bells. The main control panel shall include alarm silencing switches, system test switches, battery check switch, visual indicator for power, fault and alarm condition; and a trouble sound alarm for system fault indication. The fire alarm system shall be provided with nickel-cadmium batteries for reliable backup operation.

1.02 SYSTEM OPERATION

The fire detection main control panel shall have a capacity of at least 8 zones (expandable) in which alarm horns shall be used as the sounding device.

The activation of a manual station shall initially activate a buzzer presignal alarm at the main control of the panel. The corresponding that zone shall be lighted forewarning key personnel to investigate and evaluate the danger at the indicated area. If conditions warrant, the alarm mode can be initiated manually either by inserting a key at any manual station or at the main control panel. The system shall automatically trigger a general alarm should the presignal not be canceled at the preset time. System restart shall be effected at the main control panel.

1.03 SHOP DRAWINGS AND TECHNICAL CATALOGUES

The Contractor shall provide together with his proposal technical catalogues (3 sets) and shop drawings indicating the numbers of wires and sizes or conduits required for his equipment to properly function as required for approval by the Engineer prior to installation.

1.04 TESTING AND GUARANTEE

After completion of the system installation and at such time the Engineer may direct, the Contractor shall conduct system and equipment operational tests and make all adjustments required to fully and completely demonstrate that the system has been installed and will operate in accordance with the specifications, drawings, codes and free from any ground, shorts or defects. Copies of test results shall be provided to the Engineer and the Owner's representatives.

The Contractor shall guarantee his work, equipment for a period of not less than one (1) year from the date of final acceptance. Any part of the work or equipment that becomes defective or that will show evidence of defect or neglect during the said period shall be replaced or remedied at the expense of the Contractor without any contest.

2.00 PRODUCTS

A. Fire Alarm Devices and Detectors:
B. Fire Alarm Control Panel: Shall be expandable, with supervice bell circuits and supervice detector circuits, with capacity to support 12-volts, 2.6 AH rechargeable sealed battery, plug-in terminal block zone wiring, bell-ring and external trouble input, individual LED indicator for individual zone alarm and fault, AC-AC fault.

3.00 EXECUTION

3.01 INSTALLATION

Install fire alarm system as per manufacturer's instruction.

END OF SECTION 16721

SECTION 16726
PUBLIC ADDRESS SYSTEMS

1.00 GENERAL

1.01 DESCRIPTION OF WORK

A. Section Includes:
1. Preamplifiers.
2. Power amplifiers.
3. Transfer to standby amplifier.
4. Microphones.
5. Volume limiter/compressors.
6. Control console.
7. Equipment cabinet.
8. Equipment rack.
9. Telephone paging adapters.
10. Tone generator.
11. Monitor panel.
12. Loudspeakers.
13. Noise-operated gain controllers.
14. Microphone and headphone outlets.
15. Battery backup power unit.
16. Conductors and cables.
17. Raceways.

1.02 DEFINITIONS

A. Channels: Separate parallel signal paths, from sources to loudspeakers or loudspeaker zones, with separate amplification and switching that permit selection between paths for speaker alternative program signals.
B. VU: Volume unit.
C. Zone: Separate group of loudspeakers and associated supply wiring that may be arranged for selective switching between different channels.

1.03 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design supports and seismic restraints for control consoles, equipment cabinets and racks, and components, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.04 SUBMITTALS

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

B. Shop Drawings: For supports and seismic restraints for control consoles, equipment cabinets and racks, and components. Include plans, elevations, sections, details, and attachments to other work.
1. Detail equipment assemblies and indicate dimensions, weights, required clearances, method of field assembly, components, and location and size of each field connection.
2. Console layouts.

3. Control panels.
4. Rack arrangements.
5. Wiring Diagrams: For power, signal, and control wiring.
   a. Identify terminals to facilitate installation, operation, and maintenance.
   b. Single-line diagram showing interconnection of components.
   c. Cabling diagram showing cable routing.

C. Delegated-Design Submittal: For supports and seismic restraints for control consoles, equipment cabinets and racks, and components 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 supports and seismic restraints for control consoles, equipment cabinets and racks, and components.

D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings are shown and coordinated with each other, using input from installers of the items involved.

E. Field quality-control reports.

F. Operation and Maintenance Data: For public address and mass notification systems to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
   1. Personnel certified by NICET as Audio Systems Level III Technician.

B. Testing Agency Qualifications: Qualified agency, with the experience and capability to conduct testing indicated.
   1. Testing Agency's Field Supervisor: Currently certified by NICET at Level III to supervise on-site testing.

C. Source Limitations: Obtain public address from single source from 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 NFPA 70.

1.06 COORDINATION

A. Coordinate layout and installation of system components and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

1.07 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Microphone: One.

2.00 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Alpha Communications.
   2. Altec Lansing Technologies, Inc.
   3. Atlas Sound LP.
   4. Bogen Communications, Inc.
   5. Dukane Communication Systems; part of GE Infrastructure, Security.
   6. Edwards Signaling & Security Systems; part of GE Infrastructure, Security.
   7. Electro-Voice; Telex Communications, Inc.
   8. Federal Signal Corporation; Electrical Products Division.
   9. Rauland-Borg Corporation.
   10. Whelen Engineering Company, Inc.

2.02 FUNCTIONAL DESCRIPTION OF SYSTEM

A. System Functions:
   1. Selectively connect any zone to any available signal channel.
   2. Selectively control sound from microphone outlets and other inputs.
   3. "All-call" feature shall connect the all-call sound signal simultaneously to all zones regardless of zone or channel switch settings.
   4. Telephone paging adapter shall allow paging by dialing an extension from any local telephone instrument and speaking into the telephone.
   5. Produce a program-signal tone that is amplified and sounded over all speakers, overriding signals currently being distributed.
   6. Reproduce high-quality sound that is free of noise and distortion at all loudspeakers at all times during equipment operation including standby mode with inputs off; output free of nonuniform coverage of amplified sound.

2.03 GENERAL EQUIPMENT AND MATERIAL REQUIREMENTS

A. Compatibility of Components: Coordinate component features to form an integrated system. Match components and interconnections for optimum performance of specified functions.

B. Equipment: Comply with UL 813. Equipment shall be modular, using solid-state components, and fully rated for continuous duty unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz.

C. Equipment Mounting: Where rack, cabinet, or console mounting is indicated, equipment shall be designed to mount in a 19-inch housing complying with TIA/EIA-310-D.

D. Weather-Resistant Equipment: Listed and labeled by a qualified testing agency for duty outdoors or in damp locations.

2.04 PREAMPLIFIERS

A. Preamplifier: Separately mounted integral to power amplifier.
B. Output Power: Plus 4 dB above 1 mW at matched power-amplifier load.
C. Total Harmonic Distortion: Less than 1 percent.
D. Frequency Response: Within plus or minus 2 dB from 20 to 20,000 Hz.
E. Input Jacks: Minimum of two. One matched for low-impedance microphone; the other matchable to cassette deck, CD player, or radio tuner signals without external adapters.
F. Minimum Noise Level: Minus 55 dB below rated output.
G. Controls: On-off, input levels, and master gain.

2.05 POWER AMPLIFIERS

A. Mounting: Rack.
B. Output Power: 70-V balanced line. 80 percent of the sum of wattage settings of connected for each station and speaker connected in all-call mode of operation, plus an allowance for future stations.
C. Total Harmonic Distortion: Less than 3 percent at rated power output from 50 to 12,000 Hz.
D. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.
E. Frequency Response: Within plus or minus 2 dB from 50 to 12,000 Hz.
F. Output Regulation: Less than 2 dB from full to no load.
G. Controls: On-off, input levels, and low-cut filter.
H. Input Sensitivity: Matched to preamplifier and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on speaker microphone or handset transmitter.

2.06 TRANSFER TO STANDBY AMPLIFIER

A. Monitoring Circuit and Sensing Relay: Detect reduction in output of power amplifier of 40 percent or more and, in such event, transfer load and signal automatically to standby amplifier.

2.07 MICROPHONES

A. Paging Microphone:
1. Type: Dynamic, with cardioid polar characteristic.
2. Impedance: 150 ohms.
3. Frequency Response: Uniform, 50 to 14,000 Hz.
4. Output Level: Minus 58 dB, minimum.
5. Finish: Satin chrome.
6. Cable: C25J.
7. Mounting: Desk stand with integral-locking, press-to-talk switch.

2.08 VOLUME LIMITER/COMPRESSOR

A. Minimum Performance Requirements:
1. Frequency Response: 45 to 15,000 Hz, plus or minus 1 dB minimum.
2. Signal Reduction Ratio: At least a 10:1 and 5:1 selectable capability.
3. Distortion: 1 percent, maximum.
4. Rated Output: Minimum of plus 14 dB.
5. Inputs: Minimum of two inputs with variable front-panel gain controls and VU or decibel meter for input adjustment.
6. Rack mounting.

2.09 EQUIPMENT RACK

A. Racks: 19 inches standard, complying with TIA/EIA-310-D.
B. Power-Supply Connections: Compatible plugs and receptacles.
C. Enclosure Panels: Ventilated rear and sides and solid top. Use louvers in panels to ensure adequate ventilation.
D. Finish: Uniform, baked-enamel factory finish over rust-inhibiting primer.
E. Power-Control Panel: On front of equipment housing, with master power on-off switch and pilot light; and with socket for 5-A cartridge fuse for rack equipment power.
F. Service Light: At top rear of rack with an adjacent control switch.
G. Vertical Plug Strip: Grounded receptacles, 12 inches o.c.; the full height of rack.

H. Maintenance Receptacles: Duplex convenience outlets supplied independent of vertical plug strip and located in front and bottom rear of rack.

I. Spare Capacity: 20 percent in rack for future equipment.

2.10 TELEPHONE PAGING ADAPTER

A. Adapters shall accept voice signals from telephone extension dialing access and automatically provide amplifier input and program override for preselected zones.
   1. Minimum Frequency Response: Flat, 200 to 2500 Hz.
   2. Impedance Matching: Adapter matches telephone line to public address equipment input.
   3. Rack mounting.

2.11 TONE GENERATOR

A. Generator shall provide clock and program interface with public address and mass notification system.

B. Signals: Minimum of seven distinct, audible signal types including wail, warble, high/low, alarm, repeating and single-stroke chimes, and tone.

C. Pitch Control: Chimes and tone.

D. Volume Control: All outputs.

E. Activation-Switch Network: Establishes priority and hierarchy of output signals produced by different activation setups.

F. Mounting: Rack.

2.12 MONITOR PANEL

A. Monitor power amplifiers.

B. Components: VU or dB meter, speaker with volume control, and multiple-position rotary selector switch.

C. Selector Switch and Volume Control: Selective monitoring of output of each separate power amplifier via VU or dB meter and speaker.

D. Mounting: Rack.

2.13 LOUDSPEAKERS

A. Cone-Type Loudspeakers:
   1. Minimum Axial Sensitivity: 91 dB at one meter, with 1-W input.
   2. Frequency Response: Within plus or minus 3 dB from 50 to 15,000 Hz.
   3. Size: 8 inches with 1-inch voice coil and minimum 5-oz. ceramic magnet.
   4. Minimum Dispersion Angle: 100 degrees.
   5. Rated Output Level: 10 W.
   6. Matching Transformer: Full-power rated with four taps. Maximum insertion loss of 0.5 dB.
   7. Surface-Mounting Units: Ceiling, wall, or pendant mounting, as indicated, in steel back boxes, acoustically dampened. Front face of at least 0.0478-inch (1.2-mm) steel and whole assembly rust proofed and shop primed for field painting.
   8. Flush-Ceiling-Mounting Units: In steel back boxes, acoustically dampened. Metal ceiling grille with white baked enamel.

B. Horn-Type Loudspeakers:

1. Type: Single-horn units, double-reentrant design, with minimum full-range power rating of 15 W.
2. Matching Transformer: Full-power rated with four standard taps. Maximum insertion loss of 0.5 dB.
3. Frequency Response: Within plus or minus 3 dB from 250 to 12,000 Hz.
4. Dispersion Angle: 130 by 110 degrees.
5. Mounting: Integral bracket.
6. Units in Hazardous (Classified) Locations: Listed and labeled for environment in which they are located.

2.14 NOISE-OPERATED GAIN CONTROLLER

A. Gain controller shall be designed to continuously sense space noise level and automatically adjust signal level to local speakers.
B. Frequency Response: 20 to 20,000 Hz, plus or minus 1 dB.
C. Level Adjustment Range: 20 dB minimum.
D. Maximum Distortion: 1 percent.
E. Control: Permits adjustment of sensing level of device.

2.15 OUTLETS

A. Volume Attenuator Station: Wall-plate-mounted autotransformer type with paging priority feature.
   1. Wattage Rating: 10 W unless otherwise indicated.
   2. Attenuation per Step: 3 dB, with positive off position.
   3. Insertion Loss: 0.4 dB maximum.
   4. Attenuation Bypass Relay: Single pole, double throw. Connected to operate and bypass attenuation when all-call, paging, program signal, or prerecorded message features are used. Relay returns to normal position at end of priority transmission.
   5. Label: "PA Volume."

B. Microphone Outlet: Three-pole, polarized, locking-type, microphone receptacles in single-gang boxes. Equip wall outlets with brushed stainless-steel device plates. Equip floor outlets with gray tapered rubber or plastic cable nozzles and fixed outlet covers.

C. Headphone Outlet (for the Hearing Impaired): Microphone receptacles in single-gang boxes. Equip wall outlets with brushed stainless-steel device plates. Equip floor outlets with gray tapered rubber or plastic cable nozzles and fixed-outlet covers.

2.16 CONDUCTORS AND CABLES

A. Jacketed, twisted pair and twisted multipair, untinned solid copper.
   1. Insulation for Wire in Conduit: Thermoplastic, not less than 1/32 inch thick.
   2. Microphone Cables: Neoprene jacketed, not less than 2/64 inch thick, over shield with filled interstices. Shield No. 34 AWG, tinned, soft-copper strands formed into a braid or approved equivalent foil. Shielding coverage on conductors is not less than 60 percent.
   3. Plenum Cable: Listed and labeled for plenum installation.

2.17 RACEWAYS

A. Conduit and Boxes: Comply with Division 16 Section "Raceways and Boxes. "
   1. Outlet boxes shall be not less than 2 inches wide, 3 inches high, and 2-1/2 inches deep.

3.00 EXECUTION

3.01 WIRING METHODS

A. 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 air spaces, including plenum ceilings.
   2. Comply with requirements for raceways and boxes specified in Division 16 Section "Raceways and Boxes."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.02 INSTALLATION OF RACEWAYS

A. Comply with requirements in Division 16 Section "Raceways and Boxes" for installation of conduits and wireways.

B. Install manufactured conduit sweeps and long-radius elbows whenever possible.

3.03 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Cable Installation Requirements:
   1. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.
   2. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
   3. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
   4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
   5. 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.
   6. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used.

C. Open-Cable Installation:
   1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
   2. Suspend speaker cable not in a wireway or pathway a minimum of 200 mm (8 inches) above ceiling by cable supports not more than 60 inches apart.
   3. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.

D. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.

3.04 INSTALLATION

A. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

B. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.

C. Equipment Cabinets and Racks:
   1. Group items of same function together, either vertically or side by side, and arrange controls symmetrically. Mount monitor panel above the amplifiers.
   2. Arrange all inputs, outputs, interconnections, and test points so they are accessible at rear of rack for maintenance and testing, with each item removable from rack without disturbing other items or connections.
   3. Blank Panels: Cover empty space in equipment racks so entire front of rack is occupied by panels.

D. Volume Limiter/Compressor: Equip each zone with a volume limiter/compressor. Install in central equipment cabinet. Arrange to provide a constant input to power amplifiers.

E. Wall-Mounted Outlets: Flush mounted.

F. Floor-Mounted Outlets: Conceal in floor and install cable nozzles through outlet covers. Secure outlet covers in place. Trim with carpet in carpeted areas.

G. Conductor Sizing: Unless otherwise indicated, size speaker circuit conductors from racks to loudspeaker outlets not smaller than No. 18 AWG and conductors from microphone receptacles to amplifiers not smaller than No. 22 AWG.

H. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.

I. Speaker-Line Matching Transformer Connections: Make initial connections using tap settings indicated on Drawings.

J. Connect wiring according to Division 16 Section "Conductors and Cables."

3.05 GROUNDING

A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.

C. Install grounding electrodes as specified in Division 16 Section "Grounding and Bonding."

3.06 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. Schedule tests with at least seven days' advance notice of test performance.
   2. After installing public address and after electrical circuitry has been energized, test for compliance with requirements.
   3. Operational Test: Perform tests that include originating program and page messages at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and that system is free of noise and distortion.
   4. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:
      a. Disconnect microphone at connector or jack closest to it and replace it in the circuit with a signal generator using a 1000-Hz signal. Replace all other microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure signal-to-noise ratio.
      b. Repeat test for each separately controlled zone of loudspeakers.
      c. Minimum acceptance ratio is 50 dB.
   5. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12,000 Hz into each preamplifier channel. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.
   6. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each zone. For spaces with seated audiences, maximum permissible variation in level is plus or minus 2 dB. In addition, the levels between locations in same zone and between locations in adjacent zones must not vary more than plus or minus 3 dB.
   7. Power Output Test: Measure electrical power output of each power amplifier at normal gain settings of 50, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.
   8. Signal Ground Test: Measure and report ground resistance at pubic address equipment signal ground. Comply with testing requirements specified in Division 16 Section "Grounding and Bonding."

E. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.

F. Public address and mass notification systems will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

1. Include a record of final speaker-line matching transformer-tap settings, and signal ground-resistance measurement certified by Installer.

3.07 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
   2. Complete installation and startup checks according to manufacturer's written instructions.

3.08 ADJUSTING

A. On-Site Assistance: Engage a factory-authorized service representative to provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours

3.09 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the public address systems and equipment.

END OF SECTION 16726