SECTION 16050
ELECTRICAL GENERAL PROVISIONS

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall provide electrical and appurtenant Work necessary for a complete and operable electrical system, in accordance with the Contract Documents.

B. Make all field connections and terminations to all motors, switchgear, panels, control equipment and devices, instruments, and to all vendor-furnished packaged equipment. The requirements of this Section shall apply to all electrical items indicated in the various Sections of Division 16 unless otherwise indicated.

C. Provide all materials and incidentals required to complete the electrical Work. Typical materials which may be incidentals are terminal lugs not furnished with vendor-supplied equipment, compression connectors for cables, splices, junction and terminal boxes, and all control wires required by vendor-furnished equipment to interconnect with other equipment all specifically indicated on the Contract Documents.

D. All concrete Work required for encasement, installation, or construction of the Work specified in the various Sections of Division 16 shall be 3,000-psi concrete:

1. If encasement concrete around duct banks is required the following exceptions and supplementary requirements shall apply:
    a. Consolidation of encasement concrete around duct banks shall be by hand puddling, and no mechanical vibration shall be permitted.
    b. A Workability admixture shall be used in encasement concrete, which shall be a hydroxylated carboxylic acid type in liquid form. Admixtures containing calcium chloride shall not be used.
    c. Concrete for encasement of conduit or duct banks shall contain an integral red-oxide coloring pigment in the proportion of 8 pounds per cubic yard of concrete.

1.2 INTERFACE TO EQUIPMENT, INSTRUMENTS, AND OTHER COMPONENTS:

A. The contract drawings, specifications, and overall design are based on non-certified information furnished by various equipment manufacturers. This “equipment” includes, but not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.

B. The electrical specifications, ladder logic diagrams, and installation details are based on non-certified vendor information and indicate minimum scope of supply from Manufacturers.

C. Include all labor, material, and others costs in the bid to add additional instrument, wiring, control system inputs/outputs, controls, conduit, interlocks, electrical hardware, etc., into the Work based on the Equipment Manufacturer’s final certified Drawings.

D. Revise or produce new loop diagrams to meet the Equipment Manufacturer's wiring requirements.

E. Incorporate such changes to Instrumentation and Electrical Work at no additional cost to the Owner in light of the Contractor's knowledge that non-certified vendor information has been used in the design, and due to the fact that the final selection of the vendor may have been by the Contractor.

F. Submit all such changes and additions to the Engineer for acceptance before starting field installation Work.

G. The Contractor is responsible for providing all material and labor needed to install the actual equipment furnished, as such the Contractor's bid includes all costs to add any additional conduit, wiring, terminals, or other electrical hardware to the design, which may be necessary to make a complete, functional installation based on the actual equipment furnished:

1. Make all changes necessary to meet the Manufacturer's wiring requirements.
2. Incorporate such changes to the electrical installation into the final "As-Built" Drawings.

H. Review the complete set of Drawings and Specifications in order to ensure that all items related to the electrical power and control systems are completely accounted for. Include any such items that appears on Drawings or Specifications from another discipline in the scope of Work and any costs for these items.

1.3 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Codes and Standards

1. NFPA 30 – Flammable and Combustible Liquids Code.
2. NFPA 37 – Installation and Use of Stationary Combustion Engines and Gas Turbines.
3. NFPA 70 – National Electrical Code, latest edition.
4. NFPA 99 – General Overall Requirements.
5. NFPA 110 – Emergency and Standby Power Systems.

B. Government Standards

FS W-C-596E/GEN(1)	Connector, Plug, Receptacle and Cable Outlet, Electrical Power
FS W-S-896E/GEN(1)	Switches, Toggle (Toggle and Lock), Flush Mounted (ac)
FS WW-C-563	Electrical Metallic Tubing (EMT)
FS WW-C-581D, E	Conduit, Metal, Rigid, and Intermediate; and Coupling, Elbow, and Nipple, Electrical Conduit: Steel, Zinc Coated

OSHA	Safety and Health Standards, 29 CFR 1910 and 29 CFR 1926 as applicable

C. Commercial Standards

ANSI C80.1	Zinc Coated, Rigid Steel Conduit, Specification for
ANSI C80.4	Fittings for Rigid Metal Conduit and Electrical Metallic Tubing, Specifications for
ANSI/UL 467	Grounding and Bonding Equipment, Safety Standard for
ASTM B 3	Soft or Annealed Copper Wire
ASTM B 8	Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, and Soft
ASTM B 33	Specification for Timed Soft or Annealed Cooper Wire for Electrical Purposes
ICEA S-61-402	Thermoplastic - Insulated Wire and Cable
ICEA S-66-524, NEMA WC7	Cross-Linked, Thermosetting, Polyethylene Wire and Cable
ICEA S-68-516, NEMA WC8	Ethylene Propylene Rubber Insulated Wire and Cable
NEMA 250	Enclosures for Electrical Equipment (1,000 volts maximum)
NEMA PB-1	Panelboards
NEMA VE-1	Ventilated Cable Tray
UL 6	Rigid Metal Electrical Conduit
UL 44	Rubber - Insulated Wire and Cable.
UL 514	Electrical Outlet Boxes and Fittings
UL 886	Electrical Outlet Boxes and Fittings for Use in Hazardous Locations

D. All equipment furnished by the Contractor shall be listed by and shall bear the label of Underwriters' Laboratories, Incorporated, (UL) or an independent testing laboratory acceptable to the local Code-enforcement agency having jurisdiction.

E. The construction and installation of all electrical equipment and materials shall comply with all applicable provisions of the OSHA Safety and Health Standards (29CFR1910

and 29CFR1926, as applicable), State Building Standards, and applicable local codes and regulations.

1.4 PUBLIC UTILITIES REQUIREMENTS

A. Contact the serving agencies and verify compliance with their requirements before construction.

B. Electrical service shall be as indicated by the Contract Documents.

C. Verify, furnish, and install all service conduits, fittings, transformer pad, grounding devices, and all service wires not furnished by the serving utility.

D. Verify with the utility the exact location of each service point and type of service.

E. All charges levied by the serving utilities for permanent service will be paid for by the Owner.

1.5 PERMITS AND INSPECTION

A. Permits shall be obtained and inspection fees shall be paid for as required by local governmental jurisdictions..

1.6 CONTRACTOR SUBMITTALS

A. Shop Drawings and Catalog Data: Submit shop drawings and catalog data submittals on all motor starters, panelboards, lights, conduit, wire, switches and receptacles.

B. Submit complete material lists for the Work of this Section. Such lists shall state manufacturer and brand name of each item or class of material. Submit shop drawings for all grounding Work not specifically indicated.

C. Shop drawings are required for materials and equipment listed in other sections. Shop drawings shall provide sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications. The following shall be included:

1. Front, side, rear elevations and top views with dimensional data.
2. Location of conduit entrances and access plates.
3. Component data.
4. Connection diagrams, terminal numbers, wire numbers, internal wiring diagrams, conductor size, and cable numbers.
5. Method of anchoring, seismic requirement; weight.
6. Types of materials and finish.
7. Nameplates.
8. Temperature limitations, as applicable.
9. Voltage requirement, as applicable.
10. Front and rear access requirements.

D. Catalog data shall be submitted to supplement all shop drawings. Catalog cuts, bulletins, brochures, or the like or photocopies of applicable pages thereof shall be

submitted for mass produced, noncustom manufactured material. These catalog data sheets shall be stamped to indicate the project name, applicable Specification section and paragraph, model number, and options. This information shall be marked in spaces designated for such data in the stamp.

E. Materials and Equipment Schedules: Furnish within 30 days, a complete list of all materials, equipment, apparatus, and fixtures proposed for use. The list shall include type, sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.

F. O&M Manuals: Furnish manuals as part of the shop drawing submittals.

G. Record Drawings: In addition to the record drawings as a part of the record drawing requirements, show depths and routing of all duct bank concealed below grade electrical installations. Said set of record drawings shall be available to the Engineer during construction. After final inspection, transfer all record drawing information using a red pen to a set of drawings which shall then be delivered to the Engineer. In addition, the record drawings shall show all variations between the Work as actually constructed and as originally shown on the Drawings, based upon information supplied by the Contractor.

H. Submittal organization:

1. First page:
    a. Specification Section Reference.
    b. Name and telephone number of individual who reviewed submittal before delivery to Engineer.
    c. Name and telephone number of individual who is primarily responsible for the development of the submittal.
    d. Place the Contractor‘s review stamp and comments.
2. Next pages:
    a. Provide confirmation of Specification compliance in tabular form that individually lists each Specification section, paragraph, and subparagraph and unequivocally states compliance with said requirement or takes exception to the requirement and lists the reason for said exception and offers alternative means for compliance.
    b. Include a response in writing with each submittal packages which is re-submitted to each of the Engineer’s comments or questions:
        1) In the order that the comments and/or questions were presented throughout the submittal.
        2) Referenced by index section and page number on which the comment appeared.
        3) Acceptable responses to Engineer’s comments are either: (1) Engineer’s comments or change is accepted and appropriate changes are made or (2) Explain why comment is not accepted or requested change is not made, (3) Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.
    c. Any re-submittal, which does not contain responses to the Engineer’s previous comments shall be returned for Revision and Resubmittal.
    d. No further review by the Engineer will be performed until a response for previous comments has been received.

3. Remaining pages:
    a. Actual submittal data:
        1) Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the Specification Section.
        2) For Submittals that cover multiple devices used in different areas under the same Specification Section, the Submittal for the individual devices must list the area where the device is intended to be used.
    b. Advise all Equipment Suppliers of submittal requirements outlined in Section 16050.

I. Engineer's review:

1. The Engineer has allowed for up to and including 2 reviews of each submittal. The time and expense for any reviews beyond the allotted 2 reviews will be borne by the Contractor.

J. Material and Equipment Schedules:

1. Deliver to the Engineer a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries proposed for use, including sizes, names of Manufacturers, catalog numbers, and such other information required to identify the items.

K. Schedule of Values:

1. In addition to completing all items referred to in the schedule of values, Section 01292, submit per unit material and labor costs used in developing the final bid for the electrical system, for the express purpose of pricing and cost justification for any proposed change orders. In addition to the items shown on the schedule of values, provide per unit material and labor costs for conduit and wire installation for specific types, sizes, and locations as indicated on the Drawings and Conduit Schedule. It is the responsibility of the Electrical Contractor to prove to the Engineer's satisfaction that these per unit costs were used in the development of the final bid amount. The Owner will withhold all progress payments until said schedule of values is provided and accepted by the Engineer.

L. Roof Penetrations:

1. Submit details of all portions of the electrical installation that penetrate the roof. Include details showing support of the penetrating component, and the sealing means to be utilized.

M. Installation Recommendations:

1. Submit the Manufacturer's printed recommendations for installation of electrical equipment.

N. Record Drawings:

1. Electrical Drawings will be provided for the express purpose of being used for the Record Drawings. Maintain shop drawings for use as Record Drawings:
   a. Update Record Drawings weekly.
   b. Record Drawings must be fully updated as a condition of the monthly progress payments.
   c. Submit Record Drawings upon completions of the project for final review.
2. Clearly and neatly show all changes;
   a. Additions or changes marked in red.
   b. Deletions marked in green.
   c. Comments marked in blue.
   d. Installed systems in yellow.
   e. Invert elevations of conduit and depth below grade or floor line.
   f. Dimensions of equipment.
   g. Exact locations of equipment, underground and concealed conduit, and ductbanks.
3. Dimensioned with reference to the structures
   a. All existing pipe, conduit, wire, instruments or other structures encountered or uncovered during construction.
4. Upon completion of the Work, update all shop drawings to indicate the final As-Built configuration of the systems;
   a. Reference Section 01300 for specific requirements.
   b. Provide As-Built shop drawings for all electrical equipment
   c. Provide electronic copies of these documents when required.
5. Furnish manuals, or portions thereof, written specifically for this project.
   a. Provide electronic copies of these documents on CD-ROM disks as required.

O. Specific Submittal Requirements:

1. Furnish the submittals required by each Section in Division 16 in accordance with the following requirements.
2. Shop Drawings
   a. Required for materials and equipment listed in this and other Sections.
   b. Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
   c. Shop Drawings requirements:
      1) Front, side, and rear elevations, and top and bottom views, showing all dimensions.
      2) Locations of conduit entrances and access plates.
      3) Component layout and identification.
      4) Schematic and wiring diagrams with wire numbers and terminal identification.
      5) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
      6) Weight.

P. Calculations:

1. All required calculations to be stamped and sealed by a Professional Engineer registered in the State where the project is being constructed and specializing in the specific area required by the calculation.
2. By virtue of the fact that these calculations are being provided by a Registered Professional Engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculations means.

1.7 QUALITY ASSURANCE

A. Regulatory Requirements.

1. Perform all Work to meet the requirements of all legally constituted authorities having jurisdiction.
2. Perform all Electrical Work, whether needed for the power, control system, process, HVAC, telephone, security, etc. in accordance with all codes and standards required by Division 16.
3. Perform all Work so as to comply with the accepted editions, amendments, practices, and rulings of the applicable codes and standards, except where the Drawings and Specifications are more stringent.

1.8 DELIVERY, STORAGE, AND PROTECTION

A. Acceptance of material and equipment Furnished By Others (F.B.O.):

1. Where equipment or materials are to be F.B.O. to the Contractor for installation and connection, the Contractor must:
   a. Upon receiving such equipment or materials, make a complete check of all items and provide a transfer of materials document.
   b. Provide the transfer of materials document as a receipt detailing the products received and the condition of the products delivered to the Contractor.
   b. After Receiving and accepting the material, assume full responsibility for the safe keeping, handling, and the installation of the materials and equipment, until completed installation and final acceptance by the Engineer.
2. Failure to issue said receipt assumes that all equipment and materials were then delivered to the Contractor in the proper quantities and in perfect condition.

B. Storage and Protection:

1. Provide for the safe storage and delivery of materials, whether furnished by the Contractor or by others.
2. Replace all equipment or material, damaged before final acceptance by the Engineer in a manner acceptable to the Engineer.
3. Meet all storage requirements of the Manufacturer and provide for the safe storage of all materials and equipment as recommended by the Manufacturer.

4. Protect electrical Work at all times from damage, defacement or deterioration from any cause whatever:
    a. Provide proper storage facilities and conduct operations to this effect.
    b. Perform electrical Work in a manner as to protect the Work of other trades.

1.9 PROJECT OR SITE CONDITIONS

A. Site Conditions:

1. Provide an electrical, instrumentation and control system, including all equipment, raceways and any other components required for a complete installation that meets the Environmental conditions for the Site as specified in the General Requirements and below.
2. Seismic Classification:
    a. Provide all electrical equipment and construction techniques suitable for the seismic requirements for the Site, as specified in structural drawings
4. Altitude:
    a. The site is located at approximately 8,270 feet above mean sea level. Provide all electrical components and equipment fully rated for continuous operation at this altitude, with no additional derating factors applied.
5. Humidity:
    a. The facility is located in an area where the relative humidity is 90 percent non-condensing. Furnish all components and equipment fully rated for continuous operation at this relative humidity level.
6. Temperature:
    a. The facility is located in an area where the temperature will vary from a minimum of -20 degrees Fahrenheit to a maximum of 100 degrees Fahrenheit.
    b. Provide additional temperature conditioning equipment to maintain all equipment in non-conditioned spaces subject to these ambient temperatures 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature as determined by the equipment Manufacturer's guidelines.
7. Outdoor installations:
    a. Provide all electrical, instrumentation and control equipment installed outdoors that are suitable for operation in the ambient conditions where the equipment is located.
    b. Provide heating, cooling, and de-humidifying devices incorporated into and included with electrical equipment, instrumentation and control panels located outdoors in order to maintain the enclosures within the rated environmental operating ranges as specified in this Paragraph for the equipment:
        1) Provide all wiring necessary to power these devices.
8. Site Security:
    a. Abide by all security and safety rules concerning the Work on the Site.

1.10 AREA DESIGNATIONS

A. General: For purposes of delineating electrical enclosure and electrical installation requirements of this project, certain areas have been classified in the Contract

Documents as defined below. Electrical installations within these areas shall conform to the referenced code requirements for the area involved.

B. General Purpose Indoor Locations: Electrical Work installed in areas which are not otherwise specifically classified shall be "General Purpose." Workmanship and enclosures shall comply with the general requirements of these Specifications. Electrical power enclosures shall be NEMA Type 1 and electrical control enclosures shall be NEMA Type 12. In these areas exposed conduit shall be galvanized rigid steel conduit (GRC).

C. Outdoor and Damp Locations: In outdoor locations, raceway shall be rigid galvanized steel (GRS) conduit; entrances shall be threaded; and fittings shall have gasketed covers. Provisions shall be made to drain the fitting or conduit system. Threaded fastening hardware shall be stainless steel. Raceway supports such as hanger rods, clamps, and brackets shall be galvanized. Attachments or welded assemblies shall be galvanized after fabrication. Instruments and control cabinets, and panel enclosures shall be NEMA Type 4. Switchboard and motor control centers shall be weatherproof NEMA Type 3R. Enclosures shall be mounted 1 inch from walls to provide an air space. Locations which are indoors and 2 feet below grade elevation or which are classified as damp locations on the Drawings shall have electrical installations which conform to the requirements for outdoor locations. "Damp locations" shall include pipe galleries, tunnels, vaults, and basements. All rooms housing liquid handling equipment are also classified as damp locations regardless of grade elevation.

D. Underground Conduit or Conduit embedded in Concrete: Conduit shall be PVC coated rigid galvanized steel (GRS) conduit or Schedule 40 PVC.

E. Vaults with forced air ventilation are not considered “damp locations”. NEMA Type 12 panels will be required in these areas.

F. Splash Locations: Areas shown as splash proof shall have electrical installations as described for "outdoor locations.”

1.12 WARRANTY

A. Warrant the performance and the hardware of the complete electrical systems including all lamps, lighting, switchgear, circuit breakers, transformers, MCCs, VFD, etc. for a period of 1 year following the date of substantial completion of the Work:

1. To fulfill this obligation, provide technical service personnel designated by the Electrical Contractor and/ or Manufacturer.
2. Perform services to correct any defect within 3 calendar days after notification by the Owner of a defect.

B. Warrant the satisfactory performance of the software, equipments, and materials under the specified operating conditions.

1. In the event that operations, tests, or inspections disclose latent defects or failure to meet the specified requirements, upon notification by the Owner, promptly correct or repair any such defects or non-conformance, or furnish such new

equipment or parts as may be necessary for conformity to the specified requirements.

C. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements. Following replacement or modifications retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

D. Provide all parts, material, labor, travel, subsistence, or other expenses incurred in providing services and service visits during the warranty period:

1. Furnish spare parts and tools on site at inventory levels sufficient to meet the response and repair times specified.
   a. All spare parts and tools stored on-site become the property of the Owner upon completion of the warranty period.

1.13 MAINTENANCE

A. Provide similar items of same Manufacturer throughout the Electrical and Instrumentation portion of the project.

B. Furnish all spare parts as required by other sections of the Specifications.

PART 2 – PRODUCTS

2.1 GENERAL

A. All equipment and materials shall be new, shall be listed by UL, and shall bear the UL label, where UL requirements apply. All equipment and materials shall be the products of experienced and reputable manufacturers in the industry. Similar items in the project shall be products of the same manufacturer. All equipment and materials shall be of industrial grade and standard of construction; shall be of sturdy design and manufacture; and shall be capable of reliable, trouble-free service.

2.2 GROUNDING

A. General: All components of the grounding electrode system shall be manufactured in accordance with UL 467 and shall conform to the applicable requirements of National Electrical Code Article 250.

B. Grounding cable shall be copper. Bare copper wire shall be annealed, No. 8 AWG minimum, if not called out in the Drawings.

C. Ground rods shall conform to ANSI/UL 467 and shall be ¾-inch diameter and 8 feet in length.

1. Grounding connectors shall be high-strength copper alloy suitable for direct burial.
2. Wire connections shall be exothermic weld by Cadweld of Erico Products.
3. Manufacturers of grounding materials shall be Copperweld, Blackburn, Burndy, or equal.

2.3 UNDERGROUND DUCTS AND MANHOLES

A. General: Where an underground distribution system is required, it shall be comprised of multiple runs of single bore nonmetallic ducts, with underground manholes and pullboxes. When nonmetallic ducts are required, they shall be rigid Schedule 40 PVC for concrete encasement.

1. Manholes and pullboxes shall be of precast concrete. Concrete construction shall be designed for traffic loading.
    a. Covers shall be traffic type, except as shown otherwise. Manholes and pullbox covers designated as "HV" covers shall be identified as "High Voltage Electric," "P" shall be identified as "Secondary Electric," "C" as "Control" and "S" as "Signal." All covers shall be watertight after installation.
    b. Manholes and pullboxes shall be equipped with pulling-in irons opposite and below each ductway entrance.
    c. Manholes shall have concrete covers with 30--inch diameters lids. All covers and lids shall be bolted to cast-in-place steel frames with corrosion resistant hardware. Frames shall be factory-primed; covers shall be cast-iron and shall have pick holes or lifting handles.
2. Manholes and pullboxes shall have cable supports so that each cable is supported at 3-foot intervals within the manhole or pullbox. Cable supports and racks shall be fastened with galvanized bolts and shall be fabricated of fiberglass or galvanized steel. Porcelain insulators for cable racks shall be provided.
3. Manholes and pullboxes shall be Brooks, Quikset, U.S. Precast, or equal.

2.4 RACEWAYS

A. General: Raceway shall be manufactured in accordance with UL and ANSI standards and shall bear UL label as applicable.

B. Galvanized Rigid Steel (GRS) Conduit

1. Rigid steel conduits and fittings shall be full weight, mild steel, hot-dip galvanized and zinc bichromate coated inside and outside after galvanizing.
2. Rigid steel conduit shall be manufactured in accordance with UL Standard No. 6 and ANSI 80-1.
3. Rigid steel conduit shall be manufactured by Triangle PWC, Republic Steel, or equal.

C. Rigid nonmetallic conduit shall be Schedule 40 PVC.

1. Nonmetallic conduits and fittings shall be UL listed, sunlight-resistant, and rated for use with 90 degrees C conductors.
2. Nonmetallic conduits and fittings shall be manufactured by Carlon, Condux, or equal.

D. Flexible metallic conduit shall be fabricated from galvanized interlocked steel strip. Liquid-tight flexible metallic conduit shall have an extruded PVC covering over the flexible steel conduit. For conduit sizes 3/4 inch through 1-1/4 inches, flexible conduits

shall have continuous built in copper ground conductor. Flexible conduit shall be American Brass, Anaconda, Electroflex, or equal.

E. PVC-coated raceway system shall conform to Federal Specification WW-C-581E, ANSI C80.1, and to Underwriter's Laboratories specifications.

1. The zinc surfaces of the conduits and fittings shall remain intact and undisturbed on both the inside and the outside of the conduit through the preparation and application processing.
2. A PVC coating shall be bonded to the galvanized outer surface of the conduit. The bond between the PVC coating and the conduit surface shall be greater than the tensile strength of the plastic.
3. The thickness of the PVC coating shall be a minimum of 40 mils.
4. A PVC jacketed coupling shall be furnished with each length of conduit. A PVC sleeve equal to the OD of the conduit shall extend 1-1/2 inches from each end of coupling.
5. PVC-coated conduits shall be as manufactured by Robroy, Occidental (OCCAL), or equal.

2.5 WIRE AND CABLE

A. General: All conductors, including ground conductors, shall be copper. Insulation shall bear UL label and the manufacturer's trademark, type, voltage and temperature rating, and conductor size. Wire and cable shall be products of American, BICC/General, Rome Cable, Okonite, or equal.

B. Control Cables: All control cables shall be rated for 600 volts and shall meet the following requirements:

1. Control wires shall consist of No. 14 gage stranded copper conductors and shall be XHHW rated for 90 degrees C at dry locations and 75 degrees C at wet locations.
2. Control wires at panels and cabinets shall be machine tool grade type MTW, UL approved, rated for 90 degrees C at dry locations.

C. Instrumentation Cables: Shielded instrumentation cables shall be rated at 600 volts and shall comply with the following requirements:

1. Individual shielded cable shall consist of twisted 2 or 3 No. 16 gage, stranded, color coded, tinned-coated copper in accordance with ASTM B 33 - Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes and B 8 - Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, and Soft. Color coding shall be black-clear, or black-red-clear.
2. Insulation thickness shall be 32 mils of polyethylene, insulated with 2.3 mils 100 percent aluminum foil/polyester shield and No. 18 stranded tinned copper drain wire, all under a 32 mil PVC jacket. The shield shall be continuous and shall be grounded only at the receiving end, or as indicated.
3. Multi-individual shielded pair or triad instrumentation cable shall consist of individual shielded and twisted pair copper conductors with an ethylene-propylene insulation, and No. 18 AWG tinned stranded copper drain wire, an overall aluminum mylar shield and an overall chloro-sulfonated polyethylene

compound jacket. The cables shall be suitable for cable tray installation and shall be flame retardant.

D. Building Wire and Cable: Building wires and cables shall be rated at 600 volts and shall meet the following requirements:

1. Building wire shall be single conductor copper cable listed by UL as Type THHW rated 75 degrees C in wet locations and 90 degrees C in dry locations.
2. Building wire; **all conductors** shall be stranded.
3. No wire smaller than No. 12 AWG shall be used unless specifically indicated.

E. Cable Terminations: Cable terminations shall be in accordance with the following:

1. Compression connectors shall be Burndy "Hi Lug", Thomas & Betts "Shure Stake", or equal. Threaded connectors shall be split bolt type of high strength copper alloy.
2. Spring connectors (wire nuts) shall be 3M "Scotch Lok," "Ideal Wing Nuts", or equal.
3. Preinsulated fork tongue lugs shall be "Thomas & Betts" RC Series, Burndy, or equal.
4. General purpose insulating tape shall be Scotch No. 33, Plymouth "Slip-knot", or equal. High temperature tape shall be polyvinyl by Plymouth, 3M, or equal.
5. Epoxy resin splicing kits shall be 3M Scotchcoat 82 Series, Burndy Hy Seal, or equal.
6. Stress cone material for makeup of medium voltage shielded cable shall be by 3M- No substitutions.
7. Motor load termination kits shall be 3M.

2.6 PULL AND JUNCTION BOXES

A. Outlet, switch, pull and junction boxes for flush-mounting in general purpose locations shall be one-piece, galvanized, pressed steel. Ceiling boxes for flush-mounting in concrete shall be galvanized, pressed steel.

B. Outlet, switch, pull and junction boxes where surface mounted in exposed locations shall be cast ferrous boxes with mounting lugs, zinc or cadmium plating, and enamel finish. Surface mounted boxes in concealed locations may be pressed steel.

C. Control station, pull and junction boxes, including covers, for installation in corrosive locations shall meet the NEMA 4X requirements and shall be stainless steel or fiber glass-reinforced polyester and shall be furnished with mounting lugs.

D. All cast boxes and pressed steel boxes for flush mounting in concrete shall be fitted with cast, malleable box covers and gaskets. Covers for pressed steel boxes shall be one-piece pressed steel, cadmium plated, except that boxes for installation in plastered areas and finished rooms shall be stainless steel over plaster rings. Stainless steel plates shall be Sierra S-line, Hubbell, or equal. Cast boxes shall be as manufactured by Crouse-Hinds, Appleton, or equal.

2.7 CONDUIT FITTINGS

A. General: Fittings shall comply with the same requirements as the raceway with which they will be used. Fittings having a volume less than 100 cubic inches for use with rigid steel conduit, shall be cast or malleable nonferrous metal. Such fittings larger than one inch shall be "mogul size." Fittings shall be of the gland ring compression type. Covers of fittings, unless in "dry" locations, shall be closed with gaskets. Surface-mounted cast fittings, housing wiring devices in outdoor and damp locations, shall have mounting lugs.

B. Insulated bushings shall be molded plastic or malleable iron with insulating ring, similar to O-Z Type A and B, equivalent types by Thomas & Betts, Steel City, Appleton, O-Z/Gedney, or equal.

C. Insulated grounding bushings shall be malleable iron with insulating ring and with ground lug, - by T & B, - no substitutions.

D. Crouse Hinds UNF or UNY unions shall be used at all points of union between ends of rigid steel conduits which cannot be coupled. Running threads and threadless couplings shall not be used.

E. Liquid-tight fittings shall be manufactured by T & B, no substitutions.

F. Hubs for threaded attachment of steel conduit to sheet metal enclosures shall be similar to Appleton Type HUB, equivalent types such as manufactured by T & B, Myers Scrutite, or equal.

G. Transition fittings to mate steel to PVC conduit, and PVC access fitting, shall be as furnished or recommended by the manufacturer of the PVC conduit.

H. Conduit sealant shall be Chico, or equal.

I. Expansion fittings shall be installed wherever a raceway crosses a structural expansion joint. Such fittings shall be expansion and deflection type and shall accommodate lateral and transverse movement. Fittings shall be O-Z/Gedney Type "DX," Crouse Hinds "XD," or equal. These fittings are required in metallic and nonmetallic raceway installations. When the installation is in a nonmetallic run, a 3-foot length of rigid conduit shall be used to connect the nonmetallic conduit to the fitting.

2.8 WIRING DEVICES

A. All wiring devices shall be a product of a single manufacturer and shall conform to applicable NEMA Standards for UO series. Devices shall be as manufactured by Hubbell, Sierra, Pass & Seymour, or equal. General purpose duplex receptacles and toggle switch handles shall be ivory. Special purpose receptacles shall have a body color as shown. Receptacles and switches shall conform to Federal Specifications W-C-596E and W-S-896E, respectively.

1. Receptacles
   General purpose duplex receptacles shall be grounding type, 125-volt, ac, 20-amperes, backwired NEMA Configuration 5-20R, such as Hubbell 5362, or equal.
   a. Convenience receptacles for installation in outdoor and corrosive areas

shall be NEMA 5-20R configured and shall have stainless steel or nickel plated parts and plastic parts of Melanine.

1) Receptacles at outdoor locations shall be UL-approved for weatherproof locations with plug inserted. These shall be Crouse-Hinds, Hubbell, Pin and Sleeve Series, or equal.
2) Receptacles at damp or dry locations shall be Crouse-Hinds DS 23G, Pyle National N-1, or equal.
3) Receptacles at corrosive locations shall be Hubbell 52CM62 15 ampere, 53CM62 20 ampere, or equal.

b. Ground fault interrupter (GFI) receptacles shall be NEMA 5-20R configured and shall mount in a standard outlet box. Units shall trip at 5 milliamperes of ground current and shall comply with NEMA WD-1-1.10 and UL 943. GFI receptacles shall be capable of individual as well as "downstream" operation. GFI receptacles shall be Hubbell GF 5252, or equal.

2. Switches

a. Switches at outdoor locations shall be Crouse-Hinds DS 128, Mackworth Rees Style 3845, Joy Flexitite, or equal.
b. Switches at damp locations shall be Mackworth Rees Style 3496, Joy Flexitite, or equal.
c. Switches at dry locations shall be Crouse-Hinds DS 32G, Pyle National SCT-10k, or equal.
c. Toggle switches shall be suitable for backwiring and shall conform to the following table, or equal:

	Hubbell No.	**Bryant No.**
Single Pole	1221 (ivory)	4901I (ivory)
Three Way	12231	4903I
Momentary	15561	4821I
Four Way	12241	

2.8 CABINETS AND ENCLOSURES

A. General: All electrical cabinets and enclosures housing control relays and terminal blocks shall be manufactured in accordance with NEMA Publications 250, UL Standards 50 and 508.

1. Relay or control, and terminal cabinets shall be NEMA 4 enclosures. Sizes shown on the Drawings are minimum. Provide sufficient terminal blocks to terminate 25 percent more conductors than are shown. Interiors of cabinets shall be finished white including internal back mounting plate.
2. Floor standing NEMA 12 construction shall have three-point latching mechanism operated by oiltight key-locking handle, and shall have gasketed overlapping doors. Steel construction shall be 12-gauge; construction for wall-mounted type shall be 14-gauge steel. Exterior finish shall be ANSI 61 light gray, or equal.

B. Wiring of terminal cabinets, control or relay cabinets shall be accomplished with stranded copper conductor rated for 600-volts and UL listed as Type MTW. Wires for annunciator and indication circuits shall be No. 16 AWG. All others shall be No. 14 AWG. Color coding shall be as specified elsewhere in this Section. Incoming wires to

terminal or relay cabinets shall be terminated on a master set of terminal blocks. All wiring from the master terminals to internal components shall be factory-installed and shall be contained in 2-inch wide by 2-inch high plastic wireways having removable covers. Wiring to door-mounted devices shall be extra flexible and anchored to doors using wire anchors cemented in place. Exposed terminals of door-mounted devices shall be guarded to prevent accidental personnel contact with energized terminals.

C. All terminal block requirements shall be as manufactured by WAGO with cage clamp, Phoenix, or equal.

D. Engraving shall be as shown or as directed by the ENGINEER. Characters shall be uniform block style not smaller than 1/8-inch. Nameplates shall be secured using cadmium plated steel or other corrosion resistant screws. Adhesive alone is not acceptable.

E. Each relay or control and terminal cabinets shall be completed, assembled, wired, and tested at the factory. Test shall be in accordance with the latest UL and NEMA Standards. All cabinets shall bear UL label, as applicable.

2.9 DISCONNECT SWITCHES

A. Unfused and fused disconnect switches shall be externally operated with quick-make/quick-break mechanisms. The handle shall be interlocked with the switch cover by means of a defeatable interlock device. The switch shall be padlockable in the "off" position. Switches shall have nameplates stating manufacturer, rating, and catalog number. Heavy-duty switches shall have arc suppressors, pin hinges, and shall be horsepower rated at 600-volts. All switches rated at 100 amperes or larger shall have auxiliary contact for remote status indication. Heavy-duty switches shall be provided for all motor circuits above 3 horsepower. In smaller motor circuits switches shall be general duty.

B. Switch rating shall match the horsepower requirements of the load at the particular voltage if not otherwise shown.

C. Switch enclosure shall be NEMA 1 and shall be as manufactured by Square D, Cutler-Hammer, or equal.

2.10 ELECTRICAL IDENTIFICATION

A. Nameplates: Nameplates shall be fabricated from white-letter, black-face laminated plastic engraving stock, Formica type ES-1, or equal. Each shall be fastened securely, using fasteners of brass, cadmium plated steel, or stainless steel, screwed into inserts or tapped holes, as required. Engraved characters shall be block style of adequate size to be read easily at a distance of 6 feet with no characters smaller than 1/8-inch high.

B. Conductor and Equipment Identification: Conductor and equipment identification devices shall be either imprinted plastic-coated cloth marking devices such as manufactured by Brady, Thomas & Betts, or equal, or shall be heat-shrink plastic tubing, imprinted split-sleeve markers cemented in place, or equal.

C. Identification Tape: Identification tape for protection of buried electrical installation shall be a 6-inch wide red polyethylene tape imprinted "CAUTION – ELECTRIC UTILITIES BELOW."

2.11 LIGHTING AND POWER PANELBOARDS

A. General: Panelboards shall be dead front factory assembled. Panelboards shall comply with NEMA PB-1 as well as the provisions of UL 50 and 67. Panelboards used for service equipment shall be UL labeled for such use. Lighting panelboards shall be rated for 120/208-volt 3-phase operation or 120/240-volt for single phase operation as shown. Power panelboards shall be rated for 600 volts, 3-phase operation.

1. Interiors shall have solderless, anti-turn connectors and shall be constructed so that branch circuit breaker can be replaced without disturbing adjacent units or resorting to field drilling and tapping. Bus bars and connecting drops shall be copper. Neutral bar shall be full-sized and shall have one terminal screw for each branch circuit; main bus bar shall be full-sized for entire length. Spaces shown shall have cross connections for the maximum sized device that can be fitted.
2. Panelboard box shall be galvanized code grade steel with knockouts, and shall have removable end walls. All boxes or panelboard enclosures shall have gray baked enamel finish.
3. All circuit breakers shall be bolt-in type.

B. Lighting Panelboards

1. The main bus shall be copper and rated as shown in the panel schedule. A copper ground bar kit shall be provided and installed.
2. Cabinets for building panels shall be 20-inch wide minimum, with 4-inch minimum side gutters and 5-inch minimum top and bottom gutters. Panelboard trim shall be the same size as cabinet on surface-mounted panels and 3/4-inch larger all around than cabinet of flush-mounted panels. Doors in trim shall have typed circuit directory and pocket with protective clear plastic sheet. All trim and cabinets of surface-mounted panels in general purpose areas shall be phosphate treated, primed and finished with baked enamel, panels of flush mounted panels shall be finished to match surrounding wall color.
3. The number of circuit breakers and the ampere ratings shall be in accordance with panel schedules. Main circuit breaker or main lugs only shall be provided as indicated. The panelboard circuit breakers shall be group mounted and shall be molded case with 3- or 2-pole main breakers as required and branch circuit breakers with 10,000 AIC.
4. Surface mounted cabinets and trim in wet and damp areas shall be galvanized. Provide control enclosures under common panel trim. All panelboard doors shall be keyed alike.

2.12 PROCESS CONTROL DEVICES

A. Liquid Level Control: Liquid level controls shall be as indicated. Level settings shall be determined by Design ENGINEER and received from the ENGINEER.

1. High level flood switches shall be as shown on the drawings.

2.13 CONTROL STATIONS

A. Control stations shall comply with NEMA Standards ICS2-216. All control stations shall be industrial type, heavy duty, oil-tight, with legend plates.

B. Control stations shall be as follows:

1. Pushbutton Switch: Pushbutton switches shall be momentary type with round or square button plate. All emergency-stop pushbuttons shall have red button plates. Lock-out stop shall be momentary pushbutton with locking mechanism.
2. Selector Switches: Selector switches shall be rated 10 amperes at 600 volts and shall be rotary type with number of position and poles as indicated.
3. Indicating Lights: Pilot lights shall be full-voltage, push to test type and with plastic color caps: green color for running, yellow for ready, and red for failure status.
4. Control station enclosures shall be stainless steel, NEMA 4X in corrosive, outdoor, below grade, or wet areas.

C. Manufacturers shall be Square D with Class 9001, or equal.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Study all Drawings and Specifications and to report to the ENGINEER before bidding:

1. Any errors.
2. Any omissions
3. Any Electrical Code problems
4. Any Local Building Code problems.
5. Or any points of conflict with other trades.

B. The Electrical Contractor is required to attend a pre-bid conference and examine the premises completely before bidding. It is the Electrical Contractor's responsibility to be fully familiar with the existing conditions and local requirements and regulations. Difficulties that arise after the Contract has been awarded which could have been avoided by a more complete initial site visit are the responsibility of the Electrical Contractor to correct.

C. Review the existing site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for al wiring and cables.

D. The Contractor is responsible for the complete electrical and instrumentation Work:

1. Install extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical, power, and Process Control and Instrumentation System.

3.2 PREPARATION

A. The construction and installation of all electrical equipment and materials must comply with all applicable provisions of the:

1. OSHA-Safety and Health Standards
2. State building standards
3. Applicable local codes and regulations

B. Furnish, place, and maintain guards, night-lights, protective screens, warning signs, etc. as required to prevent accidents or injuries to all personnel.

3.3 INSTALLATION

A. Equipment locations shown on Electrical Drawings may change due to variations in equipment size or minor changes made by others during construction:

1. Verify all dimensions indicated on the Drawings:
   a. Actual field conditions govern all final installed locations, distances, and levels.
2. Review all information shown on the Contract Drawings, including architectural, structural, mechanical, instrumentation, and the accepted electrical and mechanical shop drawings, and coordinate Work as necessary to adjust to all conditions that arise due to such changes.

B. Cutting and patching:

1. Perform all cutting, patching, channeling, core drilling, and fitting required for the Electrical Work, except as otherwise directed:
   a. Actual field conditions govern all final installed locations, distances, and levels.
      1) Before cutting, channeling, or core drilling any surface, ensure that no penetration of any other systems will be made.
         a) Verify that area is clear and free of conduits, cables, piping, ductwork, post-tensioning cables etc.
         b) Use tone-locate system or X-ray to ensure that area is clear of obstructions.
      2) Review the complete Drawing set to ensure that there are not conflicts or coordination problems before cutting, channeling, or core drilling any surface.
2. Perform all patching to the same quality and appearance as the original Work. Employ the proper tradesmen to secure the desired results. Seal around all conduits, wires, and cables penetrating walls, ceilings, and floors in all locations with a fire stop material, typically:
   a. 3M CP25 Caulk
   b. 3M 303 Putty

c. T&B S-100 Caulk
d. T&B FS-500 Putty
e. T&B FST-60l Putty

3. Seal around conduit penetrations of below grade walls with a waterproof, non-shrink, nonmetallic grout. Use Fox Industries FX-225 or equal. Install in accordance with manufacturer's recommendations.

C. Install all conduit and equipment in such a manner as to avoid all obstructions and to preserve headroom and keep openings and passageways clear:

1. Install all conduits and equipment in accordance with Working space requirements as outlined in Article 110, Requirements for Electrical Installation of the National Electrical Code.

D. Earthwork and Concrete:

1. Install all trenching, shoring, concrete, backfilling, grading and resurfacing associated with the electrical work.
2. Notify the Engineer before encasing or backfilling any electrical work, and arrange for inspection.

E. Roof Penetrations:

1. Make all roof penetrations, and seal around all conduits. Use pitch pockets and flashings.
2. Roofing Contractor to make actual seals around roof penetrations.

F. Terminations:

1. Terminate all conductors required to interconnect power, controls, instruments, panels and other equipment otherwise specifically identified.

G. Miscellaneous Installation Requirements:

1. In case of interference between electrical equipment shown on the Drawings and the other equipment, notify the Engineer in writing of the proposed change:
   a. Obtain Engineer's acceptance of the proposed changes before they are made.
2. Location of manholes and pullboxes shown on Drawings are approximate. Coordinate exact location of manholes and pullboxes with mechanical and civil Work.
3. Provide additional manholes or pullboxes to those shown where they are required to make a Workable installation.
4. Circuits of different service voltage:
   a. Install in separate raceways, hand holes, pullboxes, and junction boxes.
   b. In manholes, install all cables operating at less than 50 VDC PVC coated flexible metallic conduit.
   c. The voltage and service levels are:
      1) Medium voltage: 12:47 KV
      2) Low voltage: 120V, 208V, 480V
      3) Control: less than 50VDC

H. Labeling:

1. Provide all nameplates and labels as required in specification Section 16075.

I. Equipment Tie-Downs:

1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing requirements, which apply to the site.
2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., must be permanently mounted and tied down to structures in accordance with Section 16070.

3.4 FIELD QUALITY CONTROL

A. Inspection:

1. Conduct inspection of electrical, instrumentation and control system installation in accordance with provisions outlined in Section 01450 of the General Requirements.
2. Allow Owner, Engineer, or Owner's Representative access to site for inspection of materials, equipment, or installation at any time.
3. Provide any technical data or other assistance necessary to support inspection activities.
4. Electrical inspections include, but not limited to, the following:
   a. Inspect equipment and materials for physical damage.
   b. Inspect installation of compliance with plans and specifications
   c. Inspect installation for obstructions and adequate clearances around equipment.
   d. Inspect equipment installation for proper leveling, alignment, anchorage and assembly.
   e. Inspect equipment nameplate data to verify compliance with design requirements.
   f. Inspect raceway installation quality Workmanship and adequate support.
   g. Inspect cable terminations.
   h. Schedule Structural Engineer to inspect all mounting of electrical devices and all penetrations and connections to structures.
5. Inspection activities conducted during construction do not satisfy inspection requirements outlined in each section of the Division 16 specifications.

B. Testing:

1. When the electrical Work is substantially completed, notify the Engineer that the project is ready for Field Acceptance Testing.
2. Perform the acceptance test in conformance with each section of the Division 16 specifications.
3. Record results of the required tests along with the date of test:
   a. Use conduit schedule identification numbers to indicate portion of circuit tested.

C. Workmanship:

1. Use only competent and skilled personnel experiences in their trade, Working under continuous competent supervision, to perform all Work, including installation, connection, calibration, testing, and adjustment.
   a. Perform all Work, including aesthetic as well as electrical and mechanical aspects, to standards consistent with the best practices of the trade.
2. All Work is subject to review by the Engineer or Owner at any time.
3. Provide all Work to the complete satisfaction of the Engineer or Owner.
4. Repair or replace any Work, which, in the sole opinion of the Engineer, does not conform to these Specifications, or trade practices.
5. Make all changes of any installed items to meet the intent of the Drawings and Specifications.
6. Install all materials and equipment in accordance with the Manufacturer's printed installation instructions.
   a. Where Contractor asks to deviate from the Manufacturer's recommendations, such changes shall be reviewed by the EngIneer and Manufacturer before installation.

3.5 CLEANING

A. General Requirements:

1. Maintain all surfaces to be painted in a clean and smooth condition.
2. Remove all foreign material and restore all damaged finishes to the satisfaction of the Engineer and Owner.
3. Remove all debris, rubbish, and scraps, etc. each night.
4. Leave all areas swept clean each night.
5. Wipe clean all exposed threads of conduit of the KOPR-SHIELD compound after installation.

B. Vacuum clean all electrical enclosures of any debris before any wire or cable is installed.

C. Clean and re-lamp all new and luminaries that were used in the area affected by the construction, and return all used lamps to Owner.

D. As specified in other Sections of the Specifications.

E. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:

1. Neatly coil and label spare wiring lengths.
2. Shorten re-terminate, and re-label excessive spare wire and cable lengths, as determined by the Engineer.

END OF SECTION

SECTION 16231
PACKAGED ENGINE GENERATOR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 REFERENCES

A. Institute of Electrical and Electronics Engineers.

B. National Electrical Contractors Association.

C. American Society for Testing and Materials (ASTM):

1. A53 – Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
2. A106 – Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
3. A181 – Specification for Carbon Steel Forgings for General Purpose Piping.
4. A240 – Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels.
5. A536 – Specification for Ductile Iron Castings.
6. D2310 Standard Classification for Machine-Made Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.

A. International Conference of Building Officials (ICBO):

1. Uniform Building Code (UBC).

A. International Fire Code Institute (IFCI):

1. Uniform Fire Code (UFC).

A. National Electrical Manufacturers Association (NEMA):

1. NEMA 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum)
2. NEMA MG-1 – Motor and Generators.

B. National Fire Protection Association (NFPA):

1. NFPA 30 – Flammable and Combustible Liquids Code.
2. NFPA 37 – Installation and Use of Stationary Combustion Engines and Gas Turbines.
3. NFPA 70 – National Electrical Code.
4. NFPA 99 – General Overall Requirements.
5. NFPA 110 – Emergency and Standby Power Systems.

C. Underwriters Laboratories (UL):

1. UL 142 – Standards for Steel Aboveground Tanks for Flammable and Combustible Liquids.
2. UL 508 – Industrial Control Equipment.
3. UL 2200 – Standards for Stationary Engine Generator Assemblies.

1.3 SUMMARY

A. This Section includes packaged engine-generator sets for standby power supply with the following features:

1. A single Diesel engine**.**
2. Unit-mounted cooling system.
3. Coolant Jacket heater (block heater).
4. Unit-mounted control and monitoring.
6. Batteries and battery charger.
7. Battery blanket heater.
8. Fuel system and fuel storage tank(s).
9. Exhaust system.
10. Supporting and mounting skid.
    a. Outdoor weatherproof enclosure.

B. Related Sections include the following:

1. Division 16 Section "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets. Transfer switch shall be furnished by generator manufacturer.
2. Division 16 Section “Electrical General Provisions”.

1.4 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.5 SUBMITTALS

A. Furnish complete submittals in accordance with Sections 01300 and 16050.

B. Product Data: For each type of packaged engine generator indicated. Include rated capacities at project elevation, 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.
3. Type and grade of fuel recommended.
4. Fuel and lubricating oil consumption at:
    a. 50 percent load.
    b. 75 percent load.
    c. 100 percent load.

5. Type and grade lubricating oil recommended.
6. Amount of lubricating oil required per oil change.
7. Recommended lubricating oil change periods.
    a. By hours run.
    b. By time.
8. Combustion air required.
9. Cooling air required.
10. Gauges normally furnished with engine and the normal operating range of each.
    a. Oil pressure.
    b. Coolant temperature.
    c. Base mounted fuel tank level.
    d. Fuel pressure.
11. Time interval from start-up contact closure until full load capabilities are available.
12. List of at least four installations using major components of the same type furnished for this application:
    a. Include name and telephone number of the persons most familiar with this equipment who can be contracted during the submittal review.
13. Number of cylinders, bore, stroke and piston speed.
14. RPM at 60 Hertz.
15. Size of exhaust outlet.
16. The following gaseous exhaust emissions in grams/BHP-HR and Lbs/BHP-HR:
    a. NOX
    b. HC
    c. CO
    d. Other exhaust emissions as required by the local air quality management district issuing the permit for the engine generator system.
    e. These levels shall be reported at rated speed and load as measured by SAE J177 and J215 recommended practices.
17. Voltage and frequency variation and response time with the step application and removal of 25 percent, 50 percent, 75 percent, and 100 percent of resistive load maximum.
18. Battery discharge ampere ratings at the 8 hour rate and the 1 minute rate to 1.75 volts per cell.
19. Certified published engine horsepower curves showing manufacturer's engine rating for generator set standby and prime power application.
20. Start battery catalog number and descriptive bulletin.
21. Displacement in cubic inches.
22. Compression ratio.
23. Recommended spare parts.
24. Space and ambient temperature requirements for the engine control panel.
25. Manufacturer of:
    a. Engine.
    b. Generator.
    c. Generator Control Panel.
    d. Radiator.
26. Estimated number of days to ship complete unit.

C. 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. Shipping weight of generator set.
5. Rigging Diagram: Shop drawing to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.
6. Wiring Diagrams: Power, signal, and control wiring.

D. Qualification Data: For manufacturer and testing agency.

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. 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 Manuals," include the following:

1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

G. Warranty: Special warranty specified in this Section.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

1. Maintenance Proximity: Not more than four hours' normal travel time from Installer's place of business to Project site.

B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200 miles, a service center capable of providing training, parts, and emergency maintenance repairs.

C. Source Limitations: Obtain packaged generator sets and auxiliary components 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 ASME B15.1.

F. Comply with NFPA 37.

G. Comply with NFPA 70.

H. Most of the generator features shall comply with NFPA 110 requirements for Level 2 emergency power supply system. Some of the generator set features listed in this specification shall comply with Level 1 requirements.

I. Comply with UL 2200.

J. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

K. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.7 PROJECT CONDITIONS

A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. See section 16050 of the specifications for the project conditions.
2. Ambient Temperature: Minus 20 to plus 100 deg F.
3. Relative Humidity: 0 to 95 percent.
4. Altitude: Sea level to 8270 feet.

1.8 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.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 2 years or 2000 engine hours, whichever occurs first, from date of Substantial Completion of the entire project.
2. All materials and equipment shall be guaranteed against defective materials, design, and workmanship.
3. During the warranty period, make the necessary repairs or replacements on site, where practical.
4. Warranties which mention that the part must be returned to the factory before repair are not acceptable.
5. During the warranty period, the Owner will not accept charges for:
   a. Travel time.
   b. Mileage.
   c. On-site repair labor.
6. Warranty shall list any and all items excluded.
7. If necessary, as determined by the Owner, any repairs must be made on a premium time basis.
8. Warrant base mounted fuel tank for 2-years as covered by the generator set warranty.
9. Gauge system must carry a full 2-year guarantee that provides for a no-charge visit to the site for replacement.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Caterpillar; Engine Div.
2. Generac Power Systems, Inc.
3. Kohler Co.; Generator Division.
4. Onan/Cummins Power Generation; Industrial Business Group.
5. Spectrum Detroit Diesel.

2.2 ENGINE-GENERATOR SET

A. Factory-assembled and -tested, engine-generator set.

B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.

C. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated on drawing at 80% power factor, at the elevation specified in section one of this specification. The generator set shall have capacity as required to start and operate facility loads as shown on the drawings.
2. Output Connections: As shown on the drawings.
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: 1 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. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
9. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.3 ENGINE

A. Fuel: Fuel oil, Grade DF-2.

B. Rated Engine Speed: 1800 rpm.

C. 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.

D. 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.

E. Coolant Jacket Heater (block heater): Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.

F. Governor: Adjustable isochronous, with speed sensing.

G. 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. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
4. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
   a. Rating: Shall be designed to withstand the pressure and temperature of the cooling system, and noncollapsible under vacuum.
   b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

H. 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.

I. Air-Intake Filter: Standard-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

J. Starting System: 12 or 24-Volts electric, with negative ground, depending on engine manufacture requirements.

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 level 1.

4. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycles at least twice without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length required. Include required interconnecting conductors and connection accessories.
6. Battery Heater: Factory provided, Thermostat controlled, and sized such that the battery shall be able to produce full starting power at the coldest ambient temperature specified in article one of this specification.
7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features.:
    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
    c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
    d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
    e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
    f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.4 FUEL OIL STORAGE

A. Comply with NFPA 30.
B. 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 24 hours' continuous operation at 100 percent rated power output.
3. Vandal-resistant fill cap.
4. Containment Provisions: Provide UL listed tank with secondary containment rupture basin. Tank shall be constructed to meet all local codes and requirements.

2.5 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one

or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.

D. Indicating and Protective Devices and Controls: Indications and alarms can be shown on an electronic digital readout if manufacturer chooses. These shall be 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-selection.
9. Generator-voltage adjustment.

E. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

F. Connection to Owners Monitoring System: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status listed below shall be made available to connect to the owners monitoring system.

1. Generator running.
2. Generator fail. (Common contact actuated if generator is shutdown for any of the fault conditions including the control switch in the off position.)
3. Generator alarm. (Common contact actuated for any of the alarm conditions.)

G. Remote Alarm Annunciator: Include all the audible and visual alarms to comply with NFPA 110 requirements for Level 1 systems. An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition.

1. Silencing switch in face of panel shall silence signal without altering visual indication.
2. The indicating light for the alarm event shall remain lighted until the reset button is pressed.

2.6 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 100 percent rated; complying with NEMA AB 1 and UL 489.

1. Tripping Characteristic: Designed specifically for generator protection.
2. Trip Rating: Matched to generator rating.
3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

B. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

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.
5. Ground Fault Protection: Comply with NFPA 70 for an application which is not critical to human safety.

2.7 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

F. Enclosure: Dripproof.

G. Instrument Transformers: Mounted within generator enclosure.

H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.

1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.

2.8 OUTDOOR GENERATOR-SET WEATHER PROTECTIVE ENCLOSURE

A. Description: Vandal-resistant, rust-resistant, weatherproof steel housing, provided by the generator-set manufacturer and shall be factory installed

1. Access Doors or Panels: Multiple access doors or panels shall be lockable and provide adequate access to components requiring maintenance.
   a. Doors or panels shall be keyed alike.
   b. Shall have corrosion resistant stainless steel hinges and locks with zinc plated hardware.
   c. Panels shall be removable by one person without tools.
   d. Instruments and control shall be mounted within enclosure.
2. Muffler Location: External to enclosure.
3. Wind Resistant: Up to 100 mph.

B. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 100 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.

2.9 ENGINE GENERATOR BASE

A. Support System: Bolt the engine-driven generator to welded steel base with isolation devices that are an integral part of structural support base.

B. Vibration Isolation Devices: Manufacturer shall design generator set vibration isolation devises and install between the generator and the welded steel base or between the base and the fuel tank.

1. Design of Isolator Pads: The isolator pads shall be engineered to comply with the weight of the generator-set and the seismic requirements referenced in section one of this specification.

C. Mounting Holes: The generator base or base mounted fuel tank shall be provided with mounting holes, so that the generator-set can be anchored to the concrete base.

1. Anchor Requirements: Manufacturer shall provide drawing showing mounting hole locations and the size of the anchor bolts required to anchor the generator-set.

2.10 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.11 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
2. Full load run.
3. Maximum power.
4. Voltage regulation.
5. Transient and steady-state governing.
6. Single-step load pickup.
7. Safety shutdown.
8. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
9. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.

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

3.2 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Install packaged engine-generator to provide access, without removing connections or accessories, for periodic maintenance.

C. Install packaged engine generator with vibration isolators having a minimum deflection in accordance with manufacturer recommendations on concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is referenced in Division 16 Section “Electrical General Provisions”.

D. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.3 CONNECTIONS

A. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance. All connections shall be made in accordance with the shop drawings, Manufacturer’s recommendations, and all applicable codes.

B. Ground equipment as noted on drawings and according to Division 16 Section "Electrical General Provisions."

C. Connect wiring as noted on drawings and according to Division 16 Section "Electrical General Provisions."

3.4 IDENTIFICATION

A. Identify system components."

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. The tests are listed in the following paragraphs of this article. Report results in writing.

1. Engine technician must be completely knowledgeable in the operation, maintenance, and start-up of the mechanical system.
2. Electrical technician must be completely knowledgeable in the operation, maintenance, and start-up of the electrical system.

B. Tests and Inspections:

1. Perform tests recommended by manufacturer and those tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
2. Before start-up, inspect the entire installation and all connections, both mechanical and electrical, and ensure that they are proper and consistent with all Drawings and Specifications.
    1) Inspect for physical damage.
    2) Compare nameplate rating and connection with specifications and single line diagram.
    3) Inspect for proper anchorage and grounding. Engine cooling and fuel system integrity shall be verified.

3. The factory-certified technicians, during the start-up and adjustment period, shall make sure all items furnished are in proper operating condition.
4. Certify that fuel, lubricating oil, and antifreeze conform to the Manufacturer's recommendations under the environmental conditions present.
5. Check accessories that normally function while the equipment is in standby mode for proper operation, before cranking the engine.
    a. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
        1) 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.
        2) Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
        3) Verify acceptance of charge for each element of the battery after discharge.
        4) Verify that measurements are within manufacturer's specifications.
    b. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
    c. Engine heaters.
6. 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.

C. 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.

D. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

E. Load Test: Full-load test the generating system at the site in the presence of the ENGINEER, with the Manufacturer's representative providing the necessary resistive load banks.

1. Loading shall be:
    a. 25% rated for 30 minutes.
    b. 50% rated for 30 minutes.
    c. 75% rated for 30 minutes
    d. 100% rated for 3 hours.
2. Record voltage, frequency, load current, oil pressure and coolant temperature during test. Voltage regulation, frequency stability and maximum temperature rise shall be calculated.
3. Measure radiator performance at full load including airflow, air inlet temperature and air outlet temperature.
4. Correct defects that become evident during testing.
5. Measure flows, pressures and temperatures of fuel, coolant, exhaust gas, and radiator air at inlets and outlets to system components.
6. Provide copies of the test reports to the Engineer. In accordance with submittal requirements referenced in section one.

F. Phase rotation shall be verified to determine compatibility with load requirements.

G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

1. Engine shutdown features shall be function tested:
   a. Low oil pressure.
   b. Over-temperature.
   c. Over-speed.
   d. Other features as applicable.

H. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

I. 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.

1. Report must state that the installation is complete and satisfactory.
2. List the items requiring additional attention.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's personnel regarding the operation and maintenance of the packaged engine generators. Including any and all special systems installed by them, or installed under their supervision.

1. Minimum of [**8**] hours in two [**4**] hour sessions each.
2. Supply written handouts during the training period, and these handouts should be suitable for future reference after the training period is completed.

END OF SECTION

SECTION 16415
TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, apply to this Section.

1.2 SUMMARY

A. This Section includes transfer switches rated 600 V and less, including the following:

1. Automatic transfer switches.

B. Related Sections include the following:

1. Division 16 Section “Electrical General Provisions”.

1.3 SUBMITTALS

A. Furnish complete submittals in accordance with Section 16050.

B. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.

C. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

1. Single-Line Diagram: Show connections between transfer switch, power sources, and load; and show interlocking provisions for each combined transfer switch.
2. Manufacturer Seismic Qualification Certification: The manufacturer shall submit certification of compliance that the equipment will withstand the seismic forces defined for this project as outlined by the Uniform Building Code.
3. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
4. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Qualification Data: For manufacturer.

E. Field quality-control test reports.

1. Report will show the results of the switch operation during the testing of the generator.
2. Report shall also show the settings of the control relays in the automatic transfer switch.

F. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

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.

1.4 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. 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 ICS 1.

D. Comply with NFPA 70.

E. Comply with NFPA 110.

F. Comply with UL 1008 unless requirements of these Specifications are stricter.

1.5 PROJECT CONDITIONS

A. See section 16050 of the specifications for the project conditions.

1.6 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Automatic Transfer Switches:
   a. Caterpillar; Engine Div.
   b. Emerson; ASCO Power Technologies, LP.
   c. Generac Power Systems, Inc.
   d. GE Zenith Controls.
   e. Kohler Power Systems; Generator Division.
   f. Onan/Cummins Power Generation; Industrial Business Group.
   g. Spectrum Detroit Diesel.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer.

1. Transfer switch shall be rated for the application as shown on the drawings. If the manufacturer does not provide a switch with the exact rating as shown then a switch with the next higher rating shall be used.

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.

C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.

G. Neutral Terminal: Solid and fully rated, unless otherwise indicated.

H. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.

I. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater. Heater shall be sized to prevent condensation and protect electronic devices from damage due to cold temperatures.

J. Battery Charger: If generator supplier wants the battery charger in the transfer switch for generator starting batteries. Then comply with the following.

1. Float type rated amperage output to comply with battery manufacturer recommendations.
2. Ammeter to display charging current.
3. Fused ac inputs and dc outputs.

K. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations.

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.

L. Enclosures: General-purpose NEMA 250, Type 4, complying with NEMA ICS 6 and UL 508, unless otherwise indicated. The enclosure door shall be lockable and the controls shall be protected with a lockable, vandal proof cover.

2.3 AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switching Arrangement: Double-throw type, break before make.

C. Controls shall be available on door of transfer switch to operate the switch manually.

D. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

E. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.

F. Programmed Neutral Switch Position: Switch operator has a programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Pause is adjustable from 0.5 to 30 seconds minimum and factory set for 0.5 second, unless otherwise indicated. Time delay occurs for both transfer directions. Pause is disabled unless both sources are live.

G. Automatic Transfer-Switch Features. The following settings are recommendations, if the manufacturer prefers a different setting, then he shall discuss that with the Engineer:

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. Retransfer to Normal Power Switch: Switch on door of transfer switch to bypass time delay and retransfer switch to normal power if normal power is available.
11. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is not available.

2.4 SOURCE QUALITY CONTROL

A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check the following items for compliance with specified requirements:

1. Transfer time.
2. Voltage setting.
3. Frequency setting.
4. Time-delay settings.

B. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Floor-Mounting Switch: Anchor to base by bolting.

1. Concrete Bases: Install transfer switches on 3-1/2 inch raised concrete housekeeping pad, with chamfered edges, unless otherwise indicated, as shown on the Contract Drawings. Comply with requirements for concrete referenced in Division 16 Section “Electrical General Provisions”.

B. Label the automatic transfer switch.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Ground equipment according to drawings and Division 16 “Electrical General Provisions.

C. Connect wiring according to Division 16 Section "Electrical General Provisions."

3.3 FIELD QUALITY CONTROL

A. 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 installation, including connections, and to assist in testing.
2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
4. 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.
5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
    a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
    b. Verify time-delay settings.
    c. Verify pickup and dropout voltages by data readout or inspection of control settings.

d. 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.
e. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

B. Coordinate tests with tests of generator and run them concurrently.

C. 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.

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

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below.

B. Coordinate this training with that for generator equipment.

END OF SECTION