

DIVISION 16

ELECTRICAL



SECTION 16010
ELECTRICAL – GENERAL

PART 1 - GENERAL

1.01 SUMMARY

- A. Provide complete, tested and fully functional electrical systems as shown on the Drawings and as specified herein.
- B. Electrical equipment and installed systems shall be suitable for the intended application, shall be safe for the intended use, shall be rated for the available fault current, and shall conform to local building codes and statutory requirements.

1.02 RELATED DOCUMENTS

- A. Electrical requirements specified in this Section apply to all electrical equipment and materials described in other Sections of Division 16.

1.03 PROJECT CONDITIONS

- A. Ambient temperature, humidity, and elevation ranges: Equipment shall be rated for continuous operation at full rated load without derating, under the following conditions:
 - 1. Ambient Temperature: 0 to 40 deg C.
 - 2. Humidity: Less than 90 percent (non-condensing).
 - 3. Altitude: Not exceeding 3300 feet (1000 m).

1.04 REFERENCE STANDARDS

- A. Notwithstanding revision dates shown in this and other Sections of Division 16, the codes and standards applicable to this project shall be those in effect at the time of bid opening, except for NFPA 70 (NEC), which shall be the version acceptable to the AHJ.

1.05 QUALITY ASSURANCE

- A. In consultation with the equipment and materials Suppliers, the Contractor shall prepare and submit a Compliance Statement as described in "SUBMITTALS" below with each submittal requiring approval.
- B. The Engineer's approval of a submittal shall not relieve the Contractor of any Contractor responsibilities under the Contract. Approval of a submittal that is incomplete, or one that has nonconformities that are not described in the Compliance Statement that is specified to be included with each submittal, followed by the discovery of unapproved nonconformities, will result in replacement of the non-conforming items at no additional cost to the Owner. Substitutions require the approval of the Engineer.

- C. Manufacturers of electrical equipment shall have quality certification to ISO 9000:2000 or an equivalent Quality Management System acceptable to the Engineer.
- D. Equipment, materials, and installation shall conform to NEC requirements and shall be NRTL-listed and labeled under the relevant UL standard.
- E. Manufacturers, manufacturer's representatives, subcontractors, supervisors, installers, and testing agencies shall have qualifications and experience as described in other Sections of the Specification. Qualifications and experience submittals for firms and individuals shall be submitted, re-submitted, or updated whenever requested by the Owner's Representative.

1.06 SAFETY IN THE WORKPLACE

- A. Electrical equipment and materials, and the Contractor's installation practices, shall conform to the following:
 - 1. Current edition of OSHA sections of the Code of Federal Regulations (CFR): Part 29 CFR 1910 for General Industry and Part 19 CFR 1926 for Construction Activities
 - 2. NFPA 70, the National Electrical Code
 - 3. Current edition of NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces
- B. These regulations and standards impose obligations on equipment manufacturers to obtain NRTL certification, listing, and labeling to comply with OSHA (Occupational Safety and Health Act) and Department of Labor regulations.
- C. All electrical equipment for which NRTL test procedures have been established shall be certified, listed, and labeled, or otherwise determined to be safe for its intended use, by a NRTL. The absence of a specific reference to NRTL-listing in other Sections shall not relieve the Contractor of the requirement to provide NRTL-listed equipment, and to obtain certification as required by the AHJ in cases where NRTL listing and labeling is not a manufacturer's standard offering for a particular product.
- D. Equipment shall not be modified in any manner adversely affecting safety for the intended use, nor shall any equipment be modified on-site without the approval of the manufacturer.
- E. Equipment sound levels shall not exceed limits established by reference standards and local regulations. In the absence of reference standards and local regulatory requirements, sound pressure levels shall not exceed 85-dB (A) measured three feet from the equipment.
- F. Equipment with moving parts shall be fully guarded in compliance with OSHA rules and regulations.

1.07 INSPECTIONS BY THE AHJ

- A. The Contractor shall make arrangements for electrical inspection of the project by the AHJ. Upon completion of the work, final certificate of approval documents shall be submitted to the Engineer for forwarding to the Owner. This certificate shall be submitted prior to request for final payment. The Contractor shall pay all fees required for inspection.

1.08 WORKMANSHIP AND MATERIALS

- A. Materials and equipment shall be new and undamaged, shall be marked by the manufacturer, and shall be delivered to the construction site in the original factory packaging.
- B. Materials and equipment shall be installed in accordance with the Drawings, the Specification, and the manufacturer's installation, operation, and maintenance instructions. In the event of apparent conflicts or discrepancies, the Engineer shall be informed of the apparent conflict or discrepancy in writing, and will instruct the Contractor how to proceed.

1.09 RESOURCES AND CONSTRUCTION SCHEDULE

- A. The Contractor shall provide sufficient resources, including qualified and experienced project managers, electrical engineers, superintendents, technicians, supervisors, electricians, tools and construction equipment to complete the electrical work in accordance with the activity duration's and sequences shown on the Construction Schedule for this project.)

1.010 CONTRACT DRAWINGS

- A. The Electrical Drawings provide scaled layouts of representative equipment and key building dimensions, for example, structural gridlines, but do not include "approved for construction" dimensions for equipment.

1.011 COORDINATION OF WORK

- A. Work under this Division shall be performed in conjunction with the work of other trades. Coordinate electrical installation work with the overall construction schedule. Examine the plans and specifications prior to commencement of work and become familiar with all phases of work involved prior to commencing installation work.
- B. The Contractor shall be responsible for coordinating dimensions of equipment and working clearances in accordance with NEC, and in all cases bring to the attention of the Engineer any discrepancies on the plans and in the specifications prior to installation. Any work that installed without proper coordination shall be removed and reinstalled at the Contractor's expense. The layout for sleeves chases, openings, etc., must be arranged prior to construction in order to prevent unnecessary cutting. Examine Architectural drawings for doors swings, countertop heights, built-in furniture and casework, and other factors affecting electrical outlet locations prior to roughing-in raceways, boxes, fittings, and outlets.

1.012 SUBMITTALS

- A. Submittals shall conform to the General Provisions and Special Provisions.

PART 2 - PRODUCTS**2.01 EQUIPMENT AND MATERIALS**

- A. Provide equipment and materials in compliance with other Sections of Division 16 and as noted on the drawings. The requirements in this Section apply to all Sections in Division 16.

2.02 ELECTRICAL IDENTIFICATION

- A. Electrical equipment, raceways, boxes, wires and cables shall be marked in the field in accordance with Division 16 Section "Electrical Identification"

2.03 ELECTRICAL ENCLOSURES

- A. In the absence of other specified NEMA enclosure ratings in other Sections of the Specification, the enclosure ratings shall be as noted on the drawings.

2.04 WARRANTIES

- A. Warranties for equipment and materials shall conform to the General Provisions.
- B. Provide an on-site parts and labor warranty for a minimum period of one year after Substantial Completion for all equipment and materials. In cases where the manufacturer offers a longer warranty period, the longer warranty period shall apply as described by the manufacturer.
- C. All components of electrical systems that are not fully functional at the time of Substantial Completion shall have warranties extended to provide minimum one year coverage of fully operational equipment unless otherwise approved by the Owner's Representative.

PART 3 - EXECUTION**3.01 DELIVERY AND HANDLING**

- A. Equipment delivered to site shall be handled in accordance with manufacturer's recommendations by experienced riggers, crane operators, and fork lift truck operators.

3.02 STORAGE AND PROTECTION OF EQUIPMENT

- A. All electrical equipment to be used in construction shall be properly stored and protected against the elements. General construction materials shall be stored in covered trailers. Other electrical equipment shall be stored in a clean, dry location, under cover, until ready for installation and the area where the equipment is to be installed has been completed to the satisfaction of the Engineer, including completion of overhead work by other trades.

3.03 ON-SITE INSPECTIONS AND NONCONFORMITIES

- A. Equipment shall be inspected on delivery to site for physical damage and for compliance with the Specification and approved equipment shop drawings.
- B. Installed equipment, raceways, and wiring shall be inspected on completion of installation for compliance with the Specification and approved installation drawings.
- C. A Punch List will be prepared by the Owner's Representative during inspections and testing, and issued to the Contractor for corrective action.

- D. Repairs, replacement, and other corrective action that requires de-energizing any part of the Electrical Power Distribution and Control System shall be completed prior to the scheduled date for substantial completion of the project.
- E. Submit qualifications and experience of manufacturer's proposed training personnel for approval.
- F. Additional requirements for training are described in other Sections of the Specification.

-- END OF SECTION --

SECTION 16060
GROUNDING AND BONDING

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes: Grounding systems and equipment.

1.02 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control reports.

1.03 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.01 CONDUCTORS

- A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Tinned Conductors: ASTM B 33.
 - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
 - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.02 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.
 - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.03 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet (19 mm by 3 m).

PART 3 - EXECUTION

3.01 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor. Bury at least 24 inches (600 mm) below grade.
- C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- D. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.

3.02 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1. Feeders and branch circuits.
 - 2. Lighting circuits.
 - 3. Flexible raceway runs.
 - 4. Armored and metal-clad cable runs.

3.03 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Rods: Drive rods until tops are 12 inches below final grade unless otherwise indicated.
 - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
- C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

3.04 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 - 3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal.

END OF SECTION

SECTION 16120
CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes the following:
 - 1. Wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.

1.02 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control test reports.

1.03 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.01 CONDUCTORS AND CABLES

- A. Copper Conductors: Comply with NEMA WC 70.
- B. Conductor Insulation: Comply with NEMA WC 70 for Types THW and THHN-THWN.

2.02 CONNECTORS AND SPLICES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Hubbell Power Systems, Inc.
 - 3. O-Z/Gedney; EGS Electrical Group LLC.
 - 4. 3M; Electrical Products Division.

5. Tyco Electronics Corp.
- C. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

PART 3 - EXECUTION

3.01 CONDUCTOR MATERIAL APPLICATIONS

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

3.02 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type THHN-THWN, single conductors in raceway.
- B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.
- C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.
- D. Exposed Branch Circuits: Type THHN-THWN, single conductors in raceway.
- E. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.
- F. Class 1 Control Circuits: Type THHN-THWN, in raceway.
- G. Class 2 Control Circuits: Type THHN-THWN, in raceway.

3.03 INSTALLATION OF CONDUCTORS AND CABLES

- A. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- B. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- C. Install exposed conductors in conduit parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- E. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

3.04 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- C. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION

SECTION 16130
RACEWAYS AND BOXES

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.02 SUBMITTALS

- A. Product Data: For surface raceways, wireways, and fittings.
- B. Shop Drawings: Catalog data for raceways, wireways, and fittings.

1.03 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.01 METAL CONDUIT AND TUBING

- A. Rigid Steel Conduit: ANSI C80.1.
- B. IMC: ANSI C80.6.
- C. FMC: Zinc-coated steel.
- D. LFMC: Flexible steel conduit with PVC jacket.
- E. Fittings for Conduit (Including all Types and Flexible and Liquidtight): NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
- F. Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.
- G. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

2.02 BOXES, ENCLOSURES, AND CABINETS

- A. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- B. Nonmetallic Outlet and Device Boxes: NEMA OS 2.
- C. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized, cast iron with gasketed cover.

PART 3 - EXECUTION**3.01 RACEWAY APPLICATION**

- A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
 - 1. Exposed Conduit: Rigid steel conduit.
 - 2. Underground Conduit: RNC, Type EPC-80-PVC, direct buried.
 - 3. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.
- B. Comply with the following indoor applications, unless otherwise indicated:
 - 1. Exposed: Rigid steel conduit.
 - 2. Damp or Wet Locations: Rigid steel conduit.
 - 3. Boxes and Enclosures: NEMA 250, Type 4, stainless steel in damp or wet locations.
- C. Minimum Raceway Size: 3/4-inch (21-mm) trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
 - 1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.

3.02 INSTALLATION

- A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

3.03 INSTALLATION OF UNDERGROUND CONDUIT

- A. Direct-Buried Conduit:
 - 1. Excavate trench bottom to provide firm and uniform support for conduit.
 - 2. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction.
 - 3. Install manufactured duct elbows for stub-ups at poles and equipment unless otherwise indicated.

4. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried conduits. Align planks along the width and along the centerline of conduit.

END OF SECTION

SECTION 16622
EMERGENCY GENERATOR

PART 1 GENERAL

1.1.1.01 SUMMARY

Formatted: Bullets and Numbering

- A. Work Included
 - 1. This Section includes:
 - a. One (1) permanent pad mounted generator-engine sets inside sound attenuating wrap-around enclosure. Unit shall be complete with main circuit breaker, starting batteries, battery charger, exhaust system, automatic starting panel, control panel, and all other accessories required for a complete system as shown and specified.
 - 2. The emergency generator system shall be suitable for continuous standby applications.
- B. Description of System
 - 1. The emergency generator system shall have the capacity, under load, to start and accelerate the largest connected motor with all other simultaneous loads on line.
- C. The equipment shall be rated as scheduled and as shown.

1.2.1.02 DEFINITIONS

Formatted: Bullets and Numbering

- A. Standby Rating: Power output rating equal to the power the engine-generator set delivers continuously under normally varying load factors for the duration of a power outage.
- B. 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.
- C. Steady-State Voltage Modulation: The uniform cyclical variation of voltage within the operational bandwidth, expressed in Hertz or cycles per second.

1.3.1.03 QUALITY ASSURANCE

Formatted: Bullets and Numbering

- A. Performance
 - 1. The performance of the emergency generator system including generator, engine, and transfer switch (not in contract) shall be in accordance with procedures certified by an independent testing laboratory. The manufacturer shall have successfully tested a prototype of the proposed unit.
 - 2. The emergency generator set shall be manufactured by a single manufacturer who has been regularly engaged in the production of engine-generator sets for

a minimum of ten years. The emergency generator system described herein, including these components shall be factory built, and factory tested, and shipped by this single manufacturer, so there is one source of supply and responsibilities for warranty, parts, and service. This manufacturer shall have a local representative (within 100 miles) who can provide factory-trained servicemen, required stock of replacement parts, and technical assistance.

1.4.1.04 REFERENCES

Formatted: Bullets and Numbering

- A. Materials and installation shall be in accordance with the latest revisions of the following codes, standards and specifications, except where more stringent requirements have been specified herein:
1. ANSI/NEMA MG1 Standard for Motors or Generators
 2. ANSI/NEMA 112 Standard for Test Procedures for Polyphase Induction Motors and Generators.
 3. NFPA-110 Standards for Emergency and Standby Power Systems.
 4. IEEE-126 Standard for Speed Governing of Internal Combustion Engine Generator Units.
 5. NFPA-30 Flammable and Combustible Liquids Code.
 6. NFPA-37 Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines.
 7. NFPA-70 National Electric Code
 8. UL2200 – listed and labeled under UL

1.5.1.05 SUBMITTALS

Formatted: Bullets and Numbering

- A. General
1. Submittals shall be submitted in accordance with the provisions set forth in the General Provisions.
- B. Shop Drawings
1. Prior to obtaining any material in connection with this Section, detailed shop drawings of all material shall be submitted.
 2. Submittals shall contain a material list with manufacturer data describing the material and showing its compliance with the specifications, associated standards and testing requirements.
 3. Submittals shall include:
 - a. Descriptive literature and detailed specifications
 - b. Schematics and wiring diagrams

- c. Overall outline of engine/generator set showing dimensions, base details, and weights
 - d. Front view of generator control panel
- C. O&M Manuals
- 1. Six copies of the complete operations and maintenance manual shall be submitted for each generator set. These shall include, as a minimum:
 - a. Generator Set Installation Manual
 - b. Generator Set Operator's Manual
 - c. Generator Set Parts Manual
 - d. Generator Set Control System Manual
 - e. Interconnection diagrams for Generator, Manual Transfer Switch, and Battery Charger.
- D. Record Drawings
- 1. Six copies of record drawings from the actual field installation shall be submitted for the Owner's records.

1.6.1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver engine-generator set and system components to their final locations in protective wrappings, containers, and other protection that will exclude dirt and moisture and prevent damage from construction operations. Remove protection only after equipment is safe from such hazards.

1.7.1.07 WARRANTY

- A. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace packaged engine-generator set and auxiliary components that fail in materials or workmanship within two (2) years of final acceptance and shall include labor and travel time for repairs at the jobsite for the entire warranty period.

1.8.1.08 EXTRA MATERIALS

- A. Furnish materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Indicator Lamps: Two for every six of each type used, but not less than two of each.
- C. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

Formatted: Bullets and Numbering

Formatted: Bullets and Numbering

Formatted: Bullets and Numbering

PART 2 PRODUCT**2.1.2.01 MANUFACTURERS**

- A. The following manufacturers are named to establish a standard of quality necessary for the Project:
1. Generac Model SG150 with 14.2 Liter Engine
 2. Engineer Approved Equal

Formatted: Bullets and Numbering

2.2.2.02 GENERAL

- A. The complete emergency generator system shall be factory prototype tested and shall be delivered to the site in a ready to operate condition. The emergency generator and directly associated instrumentation and controls shall be furnished by a single manufacturer. This manufacturer, or its authorized representative, shall furnish all start-up and maintenance service required by this contract.

Formatted: Bullets and Numbering

2.3.2.03 RATING

- A. See schedule on drawing for the ratings of all generators on this project. Each engine-generator set shall be mounted on a heavy-duty steel base to maintain proper alignment between components, and each set shall incorporate vibrations isolators of the type and quantity as specified by the set manufacturer, whether mounted internally or externally to the set.

Formatted: Bullets and Numbering

2.04 ENGINE

- A. General
1. Engines shall be stationary, liquid-cooled, for natural gas fuel. Design shall be two or four cycle. Engine shall be certified by the engine manufacturer as capable of driving a generator yielding a kW rating as specified herein. Engine shall be capable of driving the generator of this rating on a continuous standby basis for the duration of normal utility source interruptions per SAE J1349 conditions.
- B. Engine equipment shall include the following:
1. An electronic governor shall provide automatic frequency regulation adjustable from isochronous to 5% droop.
 2. The engine shall be cooled by a mounted closed loop radiator system rated for full load operation at 122°F (50°C) ambient as measured at the generator air inlet. Radiators shall be provided with a duct adaptor flange. The cooling system shall be filled with 50/50 ethylene glycol/water mixture by the equipment supplier. Rotating parts shall be guarded against accidental contact.
 3. An electric starter capable of three complete cranking cycles without overheating, before overcrank shutdown.

4. Positive displacement, mechanical, full pressure, lubrication oil pump. Full flow lubrication oil filters with replaceable spin-on canister elements and dipstick oil level indicator.

~~6.5.~~ Engine mounted battery charging alternator, 30-ampere minimum and solid-state voltage regulator.

Formatted: Bullets and Numbering

~~7.6.~~ Engine mounted thermostatically controlled water jacket heater to aid in quick starting. Heater shall be rated 120 volts, single phase, 60 Hz. If an alternate voltage heater is provided, contractor shall arrange for correct branch circuit at no additional cost to Owner.

Formatted: Bullets and Numbering

~~8.7.~~ Provide thermostatically controlled heating jacket for the starting batteries. Cold weather kit accessory is required.

Formatted: Bullets and Numbering

C. Base

1. The engine-generator set shall be mounted on a heavy-duty steel base to maintain alignment between components. The base shall incorporate a battery tray with holddown clamps within the rails.
2. Vibration isolators between the engine-generator and base and shall provide a minimum vibration attenuation of 95%.
3. Anchor bolts, for anchoring to a concrete base, shall be size and quantity per generator manufacturer's recommendations.

2.05 GENERATOR

A. General

1. The generator shall be of a brushless, four pole, rotating field type of drip-proof construction. The generator shall be three phase, twelve lead reconnectable.
2. The generator shall be capable of delivering rated output (kVA) at rated frequency and power factor, at any voltage not more than 5 percent above or below rated voltage.
3. A permanent magnet generator (PMG) shall provide excitation power for immunity from voltage distortion caused by non-linear loads. The PMG shall sustain excitation power for optimum motor starting and to sustain short circuit current at approximately 300% of rated current for not more than 10 seconds.
4. The automatic voltage regulator shall be temperature compensated solid-state design. The voltage regulator shall be equipped with three-phase RMS sensing. The regulator shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. The regulator shall include a torque-matching characteristic, which shall reduce output voltage in proportion to frequency below a threshold of 58 Hz. The torque-matching characteristic shall use differential rate of frequency change compensation to use the maximum available engine torque and provide optimal transient load response. Regulators which use straight-line fixed volts per hertz characteristic are not acceptable.

5. The insulation shall meet NEMA MG1 standards for Class H. Temperature rise shall not exceed 105°C at 40°C ambient.

B. Schedule

- | | | |
|----|----------------------|-------------------------------|
| 1. | Standby Power Rating | 150 kW / 60 Hz |
| 2. | Prime Power Rating | 135 kW / 60 Hz |
| 3. | Voltage | 277/480 volt, 3 phase, 0.8 pf |
| 4. | Rated Standby Amps | 226 |
| 5. | Upsized Alternator | 250 kW |

C. Features

1. Two line LCD tri-lingual digital controller
2. Isochronous electronic governor
3. Sound attenuated enclosure
4. Closed coolant recovery system
5. Smart battery charger
6. UV/Ozone resistant hoses
7. +/-1% voltage regulation
8. Natural gas
9. UL 2200 listed
10. EPA Certified

2.06 CONTROLS

- A. The control shall have automatic remote start capability from a panel-mounted 3-position (Stop, Run, and Remote) switch. Provide cycle cranking of 15 SEC (ON)/15 SEC (OFF) for three attempts (75 SEC). If engine fails to start, lockout the engine and indicate overcrank on alarm status panel.
- B. The control shall shut down and lock out upon: failing to start (overcrank), overspeed, low lubricating oil pressure, high engine temperature, or operation of a remote manual stop station. A panel-mounted switch shall reset the engine monitor and test all the lamps. Lamp indications on the control panel shall include:
 1. Overcrank shutdown - red
 2. Overspeed shutdown- red
 3. Low oil pressure shutdown - red
 4. High engine temperature shutdown - red

5. High engine temperature pre-alarm - yellow
 6. Low engine oil pressure pre-alarm - yellow
 7. Low coolant temperature - yellow
 8. Low fuel - yellow
 9. Run - green
 10. Not in automatic start - flashing red
 11. Auxiliary (two each) - red.
- C. The NEMA 1 enclosed control panel shall be mounted on the generator set with vibration isolators. A front control panel illumination lamp with ON/OFF switch shall be provided. Control panel mounted indicating meters and devices shall include:
- D. Engine Oil Pressure Gauge, Coolant Temperature Gauge, DC Voltmeter, Emergency Stop Push Button, and Running Time Meter (hours).
- E. Voltage adjusting rheostat, locking screwdriver type, to adjust voltage +/- 5% from rated value; Analog AC Voltmeter, dual range, 90 degree scale, 2% accuracy; Analog AC Ammeter, dual range, 90 degree scale, 2% accuracy; Analog Frequency/RPM meter, 45-65 Hz, 1350-1950 RPM, 90 degree scale, +/- 0.6 Hz accuracy. Seven position phase selector switch with OFF position to allow meter display of current and voltage in each phase. When supplied with reconnectable generators, the meter panel shall be reconnectable for the voltage specified.

2.07 EXHAUST SYSTEM

- A. General
1. The exhaust system shall include a silencer, piping and all required fittings and supports.
- B. Silencers
1. Silencers shall be of the critical type, with an attenuation of 25 dB or more at frequencies above 500 hertz, and 20 dB or more at frequencies 500 hertz and below. Silencers shall be sized per the requirements of the engine manufacturer and the proposed layout of the exhaust system.

2.08 MANUAL TRANSFER SWITCH (EXISTING – NOT IN THIS CONTRACT)

- A. General
1. Existing manual transfer switch is 3 Phase, 100 amps rated, double throw non-fused safety switch in NEMA 3R enclosure similar to Square D Class 3140, Series F, Part # DTU323RB. The switch has the following features:
 - a. Load make/break rated
 - b. Dual cover interlock
 - c. May be padlocked ON or OFF
 - d. Lock-off to accept up to three padlocks

- e. Side opening door
- f. Quick make/break mechanism
- g. Meets NEMA requirements as heavy duty switch
- h. UL listed as suitable for use as service equipment

2.09 BATTERY CHARGER

- A. A wall mounted float charger shall maintain battery charge while the engine is not running. The charger shall be a full wave silicon bridge rectifier compatible with the starting battery. The charger shall have the following features and characteristics:
 - 1. Output: 10 amps for 24-volt dc system, isolated from AC line.
 - 2. Float Voltage: adjustable
 - 3. DC Voltmeter: 3% accuracy
 - 4. DC Ammeter: 5% accuracy
 - 5. Protection: output current limited and self-protecting.

2.10 SOUND ATTENUATING WRAP-AROUND ENCLOSURE

- A. The engine-generator set shall be equipped standard with a sound attenuated enclosure to provide a sound level no greater than 78 dB(A). This sound level will represent the average measurement taken at eight points set equidistant, 23 feet from the set, operating at full load.
- B. The enclosure shall be weather-protective with an internal critical grade silencer with rain cap. Housing shall have hinged side-access doors and a rear see-through control door. All access doors shall be pad-lockable. The entire enclosure and skid assembly shall be treated with an electro-deposition primer process prior to finish painting for maximum durability.
- C. The silencer(s) shall be mounted within the weather protective enclosure for reduced exhaust noise and provide a clean, smooth exterior design. It shall be connected to the engine with a flexible, seamless, stainless steel exhaust connection.
- D. Provide battery powered DC Lighting for the Enclosure on a timer control.

PART 3 EXECUTION

3.01 INSTALLATION

- A. The concrete pad for the generator shall be as indicated on the drawings. Proper mounting/anchoring of generator onto concrete pad shall be per manufacturer's recommendations.
- B. Installation of the generator shall be per manufacturer's recommendations and shall be in accordance with current applicable NFPA 37 and NFPA 70 standards as well as any other federal, state and local codes for minimum distances from other structures. Sufficient room on all sides of the generator shall be provided for maintenance and servicing.

3.02 TESTING

- A. The intent of this specification is to provide equipment of proven reliability and compatibility. Three separate series of tests shall be performed: Factory Prototype Model Tests, Factory Production Model Tests, and Field Tests.
- B. Factory Prototype Model Tests: The electric generating system consisting of prime mover, generator, governor, coupling and all controls must have been tested as complete unit on representative engineering prototype model as required by NFPA 110. The tests, being potentially damaging to the equipment tested, must not be performed on equipment to be sold, but on separate prototype models as specified by NFPA 110 and their accomplishment certified by means of documentation of the tests accompanying submittal data. These tests shall have included:
1. Maximum power level (maximum kW).
 2. Maximum motor starting capacity (maximum KVA) and voltage dip recovery within seven cycles of applied load.
 3. Structural soundness (Short-Circuit and Endurance Tests).
 4. Torsiograph Analysis: The manufacturer of the engine-generator set shall verify that the engine- generator combination, as configured, is free from harmful torsional stresses. The analysis shall include correlation of empirical data from tests on a representative prototype unit. The empirical data must include spectrum analysis of the torsional transducer output within the critical speed range of the engine-generator set. Results of this analysis shall be made available to the specifier on request. Calculations based on engine and generator separately are not acceptable.
 5. Engine-generator cooling.
 6. Transient response and steady-state speed control and voltage regulations.
 7. Generator temperature rise per NEMA MG1-22.40.
 8. Harmonic analysis and voltage waveform deviation per MIL-STD-705B, method 601.4.
 9. Three-phase short-circuit test for mechanical and electrical strength with system operating at rated volts, amps, power factor, and speed, the generator terminals must be short circuited ten times on all three phases for a duration of thirty seconds. Engine-generator set must build up and perform normally without manual interventions of any kind such as resetting of circuit breakers or other tripping devices when the short circuit is removed.
 10. Failure mode test for voltage regulator. With engine-generator set operating at no load, rated speed and voltage, the AC sensing circuit to the regulator must be disconnected for a period of at least one hour. The engine-generator set must be fully operative after the test, and without evidence of damage.
 11. Endurance testing is required to detect and correct potential electrical and mechanical problems associated with typical operation.

- C. **Factory Production Model Tests:** Before shipment of the equipment, the engine-generator set shall be tested under rated load and power factor for performance and proper functioning of control and interfacing circuits. Testing at unity power factor only (resistance banks only) is not acceptable. Tests shall include:
1. Single step load pickup
 2. Transient and voltage dip responses and steady state voltage and speed (frequency) checks.
 3. The Engineer shall have the option of witnessing these tests. A summary of these test results shall be available upon request.
- D. **Field Tests After Installation**
1. The complete installation shall be initially started and checked out for operational compliance by a factory-trained representative of the engine-generator set manufacturer.
 2. Upon completing of initial start-up and system checkout, the supplier of the system shall perform a field test, with the Engineer notified in advance, to demonstrate load carrying capability and voltage and frequency stability.
 3. With the emergency load at normal operating level, a power failure is initiated by opening all switches or breakers supplying the normal power to the building or facility. Records shall be maintained at 5-minute intervals for first 15 minutes and every 15 minutes thereafter. Test data shall include time-of-day, coolant temperature, cranking time until prime mover starts and runs, time required to come up to operating speed, voltage and frequency overshoot, time required to achieve steady-state condition with all switches transferred to the emergency position, voltage, frequency, current, oil pressure, ambient air temperature, kilowatts, and power factor. Continue this load test for 2 hours observing and recording load changes and the resultant effect on voltage and frequency. Return normal power, record the time delay or retransfer for each switch (set for 15 minutes minimum) and the time delay on prime mover cool down period and shutdown.
 4. Upon completion of the above test, allow the prime mover to cool for 5 minutes. Then apply full rated load for one hour (nameplate kW) consisting of building load supplemented by a load bank if required. Unity power factor is suitable for on-site testing, provided that rated load tests at power factor have been performed by the manufacturer prior to shipment.

3.03 START-UP

- A. **Instruction**
1. The manufacturer shall provide a service representative to inspect the installation, supervise field tests and start up, to instruct all personnel involved in the generator set operation and advise personnel on the recommended maintenance procedures.
 2. Training shall be a minimum of 2 hours and shall be coordinated with the Owner so as not to cause schedule conflicts with the normal work assignments of the trainees.

16622-11

3. Upon completion of start-up and testing, the manufacturer shall submit a signed detailed report of all testing procedures and results to the Owner.

END OF SECTION

SECTION 16911**VARIABLE FREQUENCY DRIVE EQUIPMENT****PART 1 GENERAL****1.1 WORK INCLUDED**

- A. This Section shall include variable frequency drive equipment for control of each of the two (2) pump stations

1.2 ACCEPTABLE MANUFACTURERS

- A. Square D
- B. General Electric
- C. Allen-Bradley

1.3 REFERENCES

- A. Material and installation shall be in accordance with the latest revisions of the following codes, standards and specifications, except where more stringent requirements have been specified herein:
 - 1. National Electrical Code - NEC
 - 2. National Electrical Manufacturers Association - NEMA
 - 3. Underwriters Laboratories, Inc. - UL

1.4 QUALITY ASSURANCE

- A. Qualifications of Manufacturer
 - 1. All equipment furnished under this Section shall be furnished by manufacturers who meet the quality, workmanship, and experience requirements as specified in the General Provisions section of this Contract.

1.5 SUBMITTALS

- A. Submittals shall be submitted in accordance with the provisions set forth in the General Provisions.
- B. Prior to obtaining any material in connection with the Section, detailed shop drawings of all materials shall be submitted.
- C. Shop drawings shall present complete and accurate information relative to all working dimensions, equipment weights, assembly, and section views, and all necessary details pertaining to coordinating the Work of the Contract, lists of materials and finishes, parts lists and the description thereof, lists of spare parts and tools where such parts or tools are required, and any other items of information that are required to demonstrate detailed compliance with the Contract Documents. Drawings for electrical equipment shall include elementary and interconnection diagrams showing connections to internal and remote components.

D. Equipment Manuals.

PART 2 PRODUCT

2.1 VARIABLE FREQUENCY DRIVE

A. General

1. The variable frequency drive units shall be a pulse width modulation or a current source inverter type unit for use with the appropriate HP Pump.
2. The drive units shall be housed within NEMA 12 Modular Enclosures.
3. The speed and on/off status of the associated pumps shall be controlled by the Remote terminal Unit (RTU).

B. Drive and Motor Requirements

1. Drive and Motor shall be Control-Matched as a system.
2. Motor insulation system shall be inverter grade designed to meet or exceed NEMA MG1 Part 31.40.4.2 standards for resistance to spikes of 1600 volts with 0.1 microsecond rise time. The insulation shall be rated for a minimum of 1600 volts CIV at rated operating temperature.
3. The Variable Frequency Drive (VFD) shall be of sufficient capacity and provide a quality of output waveform so as to achieve full rated output of the pump. The variable frequency drive shall be capable of operating the inverter rated motor specified on this project.

C. Drive Requirements

1. Output power shall be of suitable capacity and waveform, to provide stepless speed control of the specified horsepower motor.
2. The converter shall be of the current-source or pulse width modulation type.
3. All SCRs in the rectifier and inverter sections shall be identical and interchangeable.
4. A thermal-magnetic trip circuit breaker with door-interlocked external handle shall be supplied to conveniently disconnect the incoming power.
5. The converter shall contain current limit circuitry, adjustable to 150% of motor rated full-load current to provide soft start, acceleration, and running without exceeding motor rated current. The current limit feature of the converter shall be sufficiently fast and effective so as to protect against a sudden and/or random application of a short circuit to the output terminals of the current source.
6. The power circuit design shall be such that the following conditions can occur without damage to the power circuit components.

- a. Single phase or three-phase short circuit on VFD output terminals.
 - b. Failure to commutate inverter SCR due to severe overload or other conditions.
 - c. Opening of VFD contactor during VFD operations.
 - d. Opening of VFD input circuit breaker during VFD operation.
7. To ensure safety of the equipment the VFD shall include these protective features:
- a. Static instantaneous overcurrent and overvoltage trip.
 - b. Static overspeed (overfrequency) protection.
 - c. Phase sequence detector, loss of line fuse, and undervoltage protection.
 - d. Power unit overtemperature protection.
8. Operating and monitoring devices for the converter shall interconnect with the controls as shown on the Contract Drawings. The controls shall include:
- a. Door Mounted Stop Lockout
 - b. Door mounted elapsed time meter to totalize converter running time. Display shall be six digits, hours, and tenths; nonresettable.
 - c. Provisions for remote speed control (Isolated input).
 - d. Provisions for 120 volt output to Programmable Controller for remote drive status (on).
 - e. Provisions for Remote Speed indicating meter.
9. The converter signal circuits shall be isolated from the power circuits and designed to follow a speed control signal in the remote mode and the door mounted speed control potentiometer in the local mode. The selected signal shall control the motor speed between the adjustable minimum and maximum speed settings. Maximum speed shall be field adjustable from 25% to 100% of rated speed.
10. The following conditions will cause an orderly drive shutdown:
- a. Loss of input power.
 - b. Undervoltage.
 - c. Sustained gradual overload.
 - d. Instantaneous severe overload.
 - e. SCR overtemperature.
 - f. Overvoltage.
 - g. Blown fuse.
 - h. Power supply failure.

D. Enclosure

1. The adjustable frequency converter and other electrical components and circuits that provide the operation specified shall be mounted within the NEMA 12 Modular Enclosure. The enclosure shall have hinged, front access doors with 3-point latch and handle. Electrical equipment, in addition to the adjustable frequency converter described, shall include but not be limited to:
 - a. Circuit Breaker, 480/120 volt fused control transformer, and enclosed plug-in type control relays for system functions.

PART 3 EXECUTION

3.1 INSTALLATION

A. General

1. The equipment shall be installed as shown and specified and as recommended by the drive system manufacturer.

3.2 STARTUP

A. General

B. Field Tests

1. After installation, instrumentation equipment shall be checked and the required adjustments shall be made by the representatives of the manufacturers.
2. Equipment shall be field tested in the presence of the Engineer and shall be demonstrated to operate satisfactorily over the specified ranges.
3. The Contractor shall provide the necessary test equipment and qualified test personnel.
4. In the event of failure of the field test, the Contractor shall perform the necessary corrections and retest, at his own cost and expense, the equipment as directed by the Engineer.

C. Calibration / Configuration Documentation

1. Each Drive shall be provided with a Calibration / Configuration Sheet to allow the owner to reconfigure the drive to the exact way it was installed.
2. The Calibration / Configuration Sheets shall be maintained in a binder during construction and 4 copies shall be turned over to the Owner on Completion of Start-up.
3. The Calibration / Configuration Sheets shall be organized by drive (loop) number and shall include the following types of information:

- a. Manufacture and contact information
- b. Location representative
- c. Model Number
- d. Serial Number
- e. Calibration Date
- f. Configured Range
- g. Communications configurations information
- h. Dip Switch settings
- i. Jumper positions
- j. All internal configuration values (register) required for restoring the drive to its installed state (ex: low speed limit, current limit, etc.). Factory defaults and field settings shall be documented.

3.3 SPARE PARTS AND DIAGNOSTIC EQUIPMENT

- A. Fuses
 1. The Manufacturer shall provide three spare fuses for each fuse in the complete system.
- B. Spare Parts
 1. Spare parts shall include all parts normally provided by the manufacturer for systems of similar size, construction, and purpose. All spare parts shall be packaged in separate containers with the part name and number clearly marked. These parts shall be included in the base bid.

END OF SECTION