SECTION 16620

PACKAGED ENGINE GENERATOR SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

This section specifies the furnishing and installation of a packaged electric generating plant for standby service and load bank.

1.02 REFERENCE STANDARDS

I. ANSI/NEMA MG 1 - Motors and Generators.

II. NFPA 70 - National Electrical Code.

1.03 SUBMITTALS PRIOR TO MANUFACTURE

I. **Product Data**. Submit brochures on engine, remote radiator, sound enclosure, muffler, battery, battery charger, control panel, remote alarm annunciator panel, load bank and any accessory equipment showing ratings, construction features, and performance characteristics. Indicate fuel consumption at full load.

II. **Dimensional Drawings**. ubmit dimensional drawings of packaged unit and any separately mounted accessory equipment such as batteries and charger, load bank and remote alarm annunciator panel. Include weight of the packaged unit.

III. **Electrical Diagrams**. Submit schematic and wiring diagrams of the electrical system showing all factory wiring and clearly indicating all wiring and connections to be made in the field. Include internal wiring diagrams of any packaged controllers. Indicate wattage and voltage of any electrical strip heaters. Also submit fully detailed interconnection drawings indicating each individual connection to any remote equipment, including a separate connection drawing to show point-to-point electrical wiring connections.

IV. **Mechanical and Piping Diagrams**. Submit detailed drawings showing all ductwork and piping connections to be made in the field. Indicate sizes and point-to-point piping connections between unit and remote equipment.

1.04 SUBMITTALS AFTER MANUFACTURE

I. **Factory and Field Tests**. Submit three copies of each factory and field test report on the actual packaged electric generating plant provided, indicating results for all tests described herein.

II. **Operation and Maintenance Manuals**. Two weeks prior to final inspection, deliver three sets of the manufacturer's operation and maintenance manuals

pertaining directly to the unit provided. Bind each set in a substantial binder, with each item properly indexed. Include the following information:

1- Project record drawings clearly indicating operating features and including as-built shop drawings, outline drawings, and schematic and wiring diagrams.

2- Instructions for erection, alignment including tolerances, and preparation for use.

3- Complete description of safety equipment, safety procedures and safety precautions.

4- Starting, normal running, emergency, and shutdown procedures.

5- Normal maintenance, inspection and lubrication procedures.

6- Recommended spare parts list.

1.05 WARRANTY

I. Provide manufacturer's 1-year warranty for complete genset assembly.

PART 2 - PRODUCTS

2.01 MANUFACTURER

I. Acceptable manufacturers shall have a factory-approved service organization within 100 km of the site.

2.02 DESCRIPTION

I. Provide a complete, packaged, diesel engine-electric generating plant with a remote radiator which is aligned on a single skid-type base. Make the packaged system of new, unused equipment of the manufacturer's latest design. Include all necessary instruments, devices, switches, and other appurtenances for proper operation of the unit. Supply steel safety guards around all external rotating parts. Provide a unit on which adjustments, repairs and normal maintenance are possible without the use of special tools. Provide an overall, sound attenuating housing as further described in this section. The supplier will be responsible for the proper performance of the complete unit and support systems. Transition time from the instant of failure of the normal power source to the generator source shall not exceed 10 seconds as required by NEC paragraph 700-6(b)(1).

2.03 ENGINE

I. **Type**. Provide a stationary, liquid-cooled, full diesel, compression ignition engine, either naturally aspirated or turbocharged.

II. **Rating**. Provide an engine with brake horsepower not less than 10 percent greater than required by the full load rating of the generator, including losses, and with all accessories attached.

III. **Speed**. Make engine speed suitable for direct connection to the generator without exceeding engine manufacturer's published curves. Speed must not exceed 10 rpm. Provide governor of the full hydraulic type, Woodward EGP3 with a 2301A speed controller or an approved substitution, to maintain frequency stability of any constant load, including no load, within plus or minus 1/4 percent, and to maintain frequency regulation between no load steady-state and full load steady-state within 3 percent.

IV. **Accessories**. Provide all accessories, devices and appurtenances necessary for proper operation, including but not limited to the following:

1- Lubrication System.
   a. Positive displacement mechanical lube oil pump.
   b. Full flow replaceable element oil filter.

2- Air System. Replaceable dry element air intake filter.

3- Starting System.
   a. Heavy-duty, battery-driven electric starter motor.
   b. Fully charged, lead-calcium, impact-resistant, plastic-cased, storage battery or batteries mounted on the unit or in a separate corrosion-proof rack near the unit. Make battery capacity sufficient for four cranking cycles at firing speed of 30 seconds duration each with 15-second rest periods. Provide all battery cables, connections, electrolyte, water and a hydrometer.
   c. Static, solid-state type battery charger unit which automatically controls the charge rate. Include a charging rate ammeter, a voltmeter, and a manual reset, thermal overload circuit breaker to protect the rectifier assembly and transformer. Select a charger suitable for operation at 220 volts, single phase, 60 hertz. Make charging time be 24 hours maximum. Mount charger on unit, using adequate vibration devices.
   d. Engine-driven alternator with full-wave rectifier and transistorized voltage regulator for charging battery when engine is running.

4- **Coolant System**. Closed, liquid coolant system complete with radiator, fan, coolant manifold, coolant expansion chamber (overflow tank), temperature control valve, and engine-driven coolant circulating pump. Provide a thermostatically controlled, corrosion-resistant, 220-volt a-c, engine jacket coolant heater with leads brought out to a screw terminal block and suitably identified. Fill the system with engine coolant which is a solution of at least 50 percent ethylene glycol in water.

5- **Coolant System**. A remote-mounted radiator, suitable for outdoor mounting, sized in accordance with the engine supplier's recommendation for 40c ambient. It shall include an electric motor-driven fan, fan shroud, fan core guard, surge tank, and filler with pressure cap.

If the horizontal or vertical distance between the engine and the radiator, as shown on the plans, exceeds the engine manufacturer's maximum limit, a properly coordinated heat exchanger or hot well tank and auxiliary circulating pump shall be supplied. Power for the radiator fan shall be provided by the generator along with the motor starter and necessary controls. All interconnecting wiring and conduit is to be included. All piping connections should be flexible. Isolation valves on all radiator lines shall be full port. All coolant required for a completed fully-piped system shall be included. Thermostatic controls for the jacket and intercooler system shall be included. The following are the maximum permissible sound pressure levels allowed 1 meter below the fan ring of each remote radiator in free field conditions.

Octave Band Center Frequency, Hz	63	125	250	500	1000	2000	4000	8000
Max. Sound Pressure Level, dB re 10^{-12} watts	97	97	98	96	93	90	85	69

6- **Exhaust System**. High degree, critical-rated muffler with maximum silencing capacity mounted horizontally on top of unit. Include an 45 cm length of flexible stainless steel exhaust tubing for mounting on outlet side of muffler. Provide exhaust condensation trap and a rain cap on exhaust end of tubing. The generator engine exhaust, with the muffler in place, shall have the following maximum permissible sound pressure levels:

Octave Band Center Frequency, Hz	63	125	250	500	1000	2000	4000
Max. Sound Pressure Level, dB re 10^{-12} watts	71	62	88	74	74	72	70

7- **Fuel System.**

a. Engine-driven, self-priming fuel injection pump suitable for injecting fuel from the day tank to the engine.
b. Day tank with float switch mounted in skid base of unit and having a minimum capacity for operating unit at full load for 3 hours.
c. Full flow replaceable element fuel filter.
d. Flexible fuel connection lines between day tank and engine.

e. Check valve in fuel line at day tank to prevent fuel line from emptying back into tank.
f. Tank shall be tank-in-tank construction. Interstitial space shall have a fuel sensor to detect a leak in the inner tank. The alarm shall be on the remote alarm panel.

8- **Field Connections**. Flanges for all field connection shall be flush with the surface of the acoustical enclosure. No field connections are to be made inside the enclosure. All mechanical flex connectors between the enclosure and field piping are to be provided by the manufacturer.

2.04 GENERATOR

I. **Type**. Furnish a direct-coupled, synchronous, brushless-type generator with amortisseur windings, revolving field P.M.G., exciter, 2/3 pitch built-in static rectifier and automatic voltage regulator.

II. **Rating**.

1- Voltage: 400/220, three phase, four wire, grounded neutral.

2- Frequency: 50 hertz.

3- Kilowatts: as noted on plans.

4- Power Factor: 0.8

5- Duty: Standby duty, used with large non-linear loads.

6- Overload: Generator shall be sized to accommodate a 110 percent load for 8 hours.

7- Enclosure: NEMA 1, indoor type enclosure.

III. **Insulation System**. Class H.

IV. **Temperature Rise**. Class B (80 C rise over a 40 C ambient).

V. **Instantaneous Voltage Dip**. Less than 15 percent when a full load is applied. Less than 15 percent when a full load is removed.

VI. **Voltage Regulator**. $\pm$ 1/4 percent regulation - no load to full load with under-frequency protection, 3-phase sensing and loss of sensing shut-down. Input power shall be received from P.M.G.

VII. **Enclosure**. IP20

VIII. **Stator**. Shall be 2/3 pitch. Windings must be true form-wound coils incorporating rectangle wire, V.P.I. and additional epoxy overcoat for increased moisture protection.

IX. **Coupling**. From engine, drive rotor through a semi-flexible coupling to ensure permanent alignment.

X. Provide under-frequency protection for the generator.

XI. Provide an oversized generator termination cabinet.

2.05 CONTROL PANEL

Mount control panel on unit and include, but do not limit to, the following instruments and protective devices.

I. A-c ammeter having a 5-ampere movement with scale not smaller than 120 percent nor larger than 175 percent of full load current.

II. Four-position ammeter switch with positions A, B, C and OFF.

III. Three current transformers; 5-ampere secondary, primary to match ammeter full scale.

IV. A-c voltmeter with scale 0-600 volts.

V. Seven-position voltmeter switch with positions A-B, B-C, C-A, A-N, B-N, C-N and OFF.

VI. Automatic solid-state voltage regulator.

VII. Exciter field rheostat for adjusting voltage plus or minus 5 percent of rated voltage.

VIII. Frequency meter with a scale indicating from 90 to 110 percent of rated hertz.

IX. Governor control.

X. Fine speed adjustment knob.

XI. Non-resettable elapsed time meter with a 9,999.9-hour maximum indication.

XII. Coolant temperature gauge.

XIII. Battery charge-rate ammeter or voltmeter.

XIV. Oil pressure gauge.

XV. Main circuit breaker, 100 percent rated, with trip set as recommended by generator manufacturer.

XVI. Combination alarm-shutdown system with manual reset and indicating lights for high engine temperature, low engine temperature, low oil pressure, engine overspeed and engine failed to start. Include an additional set of contacts for remote alarms.

XVII. Provide a relay that energizes when the engine is operating. The output contacts from each machine will be connected in parallel such that when any of the generators start, the diesel pumps will be given a start signal. This relay shall also start the remote radiator fan.

XVIII. HAND-OFF-AUTOMATIC selector switch for control of engine.

XIX. Battery-operated panel lights.

XX. Vibration isolators for control panel.

2.06 ENGINE START-STOP CONTROLS

Provide controls in the control panel for starting and stopping the engine, including the following:

I. Three-Position Selector Switch. Mount on front of the control panel with the following positions labeled.

1- HAND: To permit starting the engine from the panel for test purposes, without load transfer.

2- OFF: To stop engine and disconnect control for prevention of start during maintenance and to reset automatic controls. Provide extra contact for remote alarm.

3- AUTOMATIC: To set up circuits for automatic start and stop on demand of remote mounted transfer switch or exerciser.

II. Automatic Cranking.

1- Crank control and time delay relays to provide a minimum of four intermittent crank periods. Use a crank limiter to limit total crank time plus rest time to 45 seconds maximum. Use adequate rest periods for battery provided.

2- Make cranking cycle terminate immediately on engine start-up by a fuel pressure switch or some other acceptable means.

III. Cool-down Period. An adjustable from 5 to 30 minute time delay for unloaded running of the engine generator after retransfer of the load to the normal source.

IV. Exerciser. An adjustable exerciser to automatically run the unit unloaded from 10 to 60 minutes every 7 days. Design exerciser so that no interruption of normal power to the load will occur.

2.07 REMOTE ALARM ANNUNCIATOR PANEL

I. Provide remote audiovisual alarm panel in BMS control room, in accordance with NFPA 99, wired in parallel. Mount a lamp TEST pushbutton and an audible SILENCE pushbutton on the front of the panel. Provide General Electric No. 755 lamps with a transformer or LED lights. Provide indicating lights to signal:
Not-in-Auto (flashing red)
Overcrank (red)
Emergency Stop (red)
High Engine Temperature (red)
Overspeed (red)
Low Oil Pressure (red)
Air Damper (red)
Battery Charger Malfunction (red)
Low Battery Voltage (red)
Low Fuel (red)
Auxiliary Pre-alarm (yellow)
Auxiliary Fault (red)
System Ready (green)
Pre-alarm High Engine Temperature (yellow)

Pre-alarm Low Oil Pressure (yellow)
Low Coolant Temperature (red)
Day Tank Fuel Leak (red)
High Crankcase Pressure (red)

II. Terminals shall be provided for each signal above plus additional terminals for common fault and common alarm.

2.08 BASE

I. Mount the assembled packaged unit on a skid base of welded structural steel, box-type construction. Use vibration isolators of either steel spring or neoprene construction. Prime all exposed metal parts with a rust inhibitor and finish in durable machinery enamel. Vibration isolation shall be provided and shall be sized for 8 cm of static deflection.

2.09 SOUND ATTENUATION HOUSING

I. **Construction**. Provide an overall housing with removable side panels and a hinged, padlockable meter panel door. Unitized construction between the stud and the acoustical enclosure. The maximum sound level measured one meter from the enclosure in free field conditions under full load shall not exceed 85 dBA.

II. **Painting**. Prime all exposed metal parts with a suitable rust inhibitor applied to the clean, bare metal followed by two coats of an epoxy paint.

III. **Acoustical Treatment**. Intake and exhaust silencers shall be provided at the ends of the skid.

IV. **Ventilation Fans**. A ventilation fan or fans shall be provided in the enclosure. The fans shall provide the CFM requirements for the combustion air and for removing radiant heat from the generator and the engine and maintain a –1°C temperature rise in the enclosure. In addition to the static pressure requirements for the enclosure, the fans shall also be able to overcome an additional 10 mm of water in static pressure. All motor starters and associated control and wiring shall be included. Power for the fans shall be derived from the generator. The ventilation flow shall be from the generator end to the engine end. An acoustic treated duct shall be provided between the exhaust silencer and the louver in the wall.

2.10 FACTORY TESTS

I. Before delivery to the job site, have each engine generating plant with enclosure and radiator satisfactorily tested as a unit as described in the following paragraphs and in accordance with the manufacturer's design parameters. The test procedure shall simulate the head requirements for the cooling water that are required to be met in the field conditions.

II. **Shutdown Tests**. Bring the engine generator to stable operation and then create the following conditions in turn to cause alarm and shutdown.

1- High engine temperature.

2- Low engine temperature.

3- Low oil pressure.

4- Engine overspeed.

III. **Voltage and Frequency Stability Tests**. Have the engine generator carry rated kW load at 0.8 power factor for 1 hour. During this test, frequency and voltage must not vary more than parameters stated in this section.

IV. **Full Load Tests**. Start the generator under no load and then have full rated kW at 0.8 power factor applied in a single increment within 10 seconds of start-up. Remove the load from the unit 5 minutes after start-up and then reapply full rated kW at 0.8 power factor 30 seconds later. Run the unit an additional 5 minutes under load before shutdown. During this test, the instantaneous voltage dip must not exceed that stated in paragraph 2.4E of this section, and frequency and voltage regulation must not vary more than parameters stated in this section with strip chart recorders. Unit shall be tested for 6 hours at 100 percent rated load and then at 110 percent of rated load for 2 hours with enclosure installed and using the radiator to be furnished with the unit.

2.11 TOOLS

I. Provide one set of any special tools other than standard wrenches required for preventative maintenance of the genset assembly. Package tools in an adequately sized metal tool box.

2.12 LOAD BANK

I. A load bank is required for periodic exercising and testing of the standby emergency power source. The load bank is to be permanently mounted, outdoors, and will be a forced air cooled resistive load bank with a remotely mounted control panel

II. **Rating**.

1- The total capacity of the load bank will be as noted on plans at 220 volts, 3 phase, with unity power factor.

2- Load steps shall be arranged so that the minimum load step is 100KW. The tolerance of each load step shall be -0 KW, +5 percent of rated KW.

3- The load bank shall be a 3-phase, 3-wire design which will operate from 45-55Hz.

4- Duty cycle is continuous, and the load bank shall operate in an ambient temperature of -37EC to 50EC (-35EF to 120EF).

III. Construction.

1- The load bank shall be constructed of heavy-gauge aluminized steel or hot-dipped galvanized after construction.

2- Controls will be contained in an integrally mounted control cabinet or cabinets which have hinged lockable doors with rubber gasketing to protect contactors from weather. A thermostatically controlled heater in each such enclosure will protect contactors from condensation.

3- Air flow shall be horizontal. Fixed louvers shall be provided on the inlet and exhaust openings, and the vendor must certify that the load bank will withstand 3 cm of rain per hour, at a 45-degree angle, from any of four directions.

4- The load bank shall conform to NEMA 3R. The control cabinet or cabinets shall conform to NEMA 3R, as modified to allow drain holes in opposite corners of the bottom. The load bank roof shall be pitched to eliminate standing water.

5- Intake and exhaust openings shall be further screened with a mesh capable of admitting objects no greater than 2 cm diameter. This mesh shall be galvanized per ASTM A 390-66 or zinc plated per ASTM B 633-85 prior to any painting or other coating. The entire load bank exterior, with the exception of louvers, shall be painted with a two-part polyurethane enamel paint at a minimum 2 mils dry film thickness with a spatter finish.

6- Load elements (resistors) shall be contained in one or more heater cases or trays, which can be removed in their entirety as a unit if service ever becomes necessary.

7- The load bank shall include forklift channels for lifting.

8- All exterior fasteners shall be stainless steel.

IV. Load Elements (Resistors).

1- Resistors shall be open helically wound chromium alloy electrical resistance wire. The entire length of each resistive element shall be rigidly supported and insulated by means of ceramic insulators so that a broken wire will not short to an adjacent wire or ground.

2- The resistors shall be contained in welded heater cases. Main structural elements of these shall be constructed of aluminized steel per ASTM A 463 or any material which exceeds these requirements in corrosion resistance.

V. Cooling.

1- The load bank shall be designed for cooling by an integral fan. To ensure against hot spots, the load bank shall be designed so that at maximum load, resistors operate at no more than 50 percent of the maximum continuous temperature rating of the resistance wire used.

The fan shall be sized by the load bank manufacturer and provide the required air flow requirements. Review the contract drawings for possible air flow obstructions. Any obstructions are existing and may not be modified.

2- The fan motor must be electrically protected against overload and short circuit using a motor overload device and fuses with an interrupting rating of 100K AIC.

3- The motor must be rigidly supported from the front and the rear by structural members which attach to the frame of the load bank, not just a bracket attached to the fan venturi. Supplemental torsional stabilizers must be provided to ensure structural integrity.

VI. **Control Circuitry Cabinet.**

1- Electrical contactors, fuses and circuitry to remove the load if air flow is blocked shall be included in the control equipment cabinet or cabinets. All controls contactors, etc., shall be included. All power required is to be derived from the generator at 220V. Any other power requirements are the responsibility of the Contractor.

2- All bus bars in the control enclosures, and elsewhere in the load bank, shall be tin-plated copper.

VII. **Control Panel**. The control panel shall be a wall-mounted control panel in a NEMA 1 enclosure. It shall contain a power ON/OFF switch, a power ON indication light, blower ON/OFF pushbuttons, and a blower FAILURE light. Load selection shall include a master load ON/OFF switch and individual switches to turn ON or OFF each load step.

PART 3 - EXECUTION

3.01 INSTALLATION

I. Follow manufacturer's installation procedures. Have installation supervised and approved by a qualified representative of the unit manufacturer.

II. Install packaged electric generating plant on a concrete pad in accordance with Section 16010, Electrical General Provisions.

3.02 ENGINE EXHAUST

I. Install an exhaust tubing between engine exhaust outlet and muffler inlet. Turn muffler tailpipe up and terminate with rain cap.

3.03 FAN DISCHARGE

I. Provide an acoustically lined elbow to direct radiator fan discharge up. Make drain holes in bottom so rain water will not accumulate. Brace elbow structurally with steel that has been hot-dip galvanized after all cuts and holes

have been made. Support system must be approved for strength, finish and appearance.

3.04 FIELD TESTS

I. Perform field tests at the site after installation is complete and in the presence of the Engineer.

II. **Manufacturer's Representative**. Have the engine generator manufacturer furnish a representative to operate each unit during the field tests, to check all details of the installation, and to instruct the operators. Include, at no additional cost to the Engineer, the services of the representative.

III. **Preparation for Testing**. Have the engine generator system completed and ready for operation at the time field tests are to be run. Fill fuel tanks, provide all necessary lube oil and coolant, and install new, unused oil and air filter elements.

IV. **Instruments**. Provide all instruments necessary to conduct the tests.

V. **6-Hour Test**. Notify Engineer 14 days before each test. Then complete a 6-hour, full-load test and 1-hour 110 percent load test using load bank as a condition for final acceptance. Read and record all gauges and meters before starting the test, then every 10 minutes during the first hour, and then every half hour during remainder of the 7-hour period. Remove load and run engine generator at no load for 15 minutes; then shut unit down and immediately make one last recording of all gauge and meter indications. Have recordings field witnessed during test by the Engineer. Deliver three copies of such witnessed recordings to the Engineer within one week of the test. Generator set supplier shall include testing relative load bank and all necessary cabling. All fuel and other fluids required for testing to be provided by the genset supplier.

VI. **Actual Plant Load Tests.**

1- After the successful 6-hour, full-load field test described above, make additional on-site tests using actual available plant loads in the presence of the Engineer to demonstrate satisfactory performance of the complete engine generator system. Include different sequenced start-ups of the various specified loads, as directed by the Employer.

2- As a final test, after all other tests have been successfully completed, operate the engine generator system under actual available plant loads for 4 hours of successful operation.

3- After final testing, refill all fuel tanks.

3.05 TRAINING

I. Formal training for the operation and maintenance of all packaged electric generating plant equipment and each system specified herein shall be given by factory trained and certified personnel. The training shall consist of a minimum of four 4-hour training sessions. The timing of the training should

coincide with the schedule for the manufacturer's representatives to be on site for testing and start-up of the systems. The specified training shall be given at a location designated and provided by the Employer for a minimum of 2 personnel selected by the Employer, in addition to any necessary on-site orientation and training. A training program shall be submitted with material, instructors' qualifications, and proposed schedule, a minimum of 30 days prior to the proposed training. The Engineer reserves the right of approval of any training course, material, instructor and schedule. A minimum of 3 bound copies of training material shall be provided at the time of training, with four additional copies submitted at the time of Substantial Completion included in the Employer rs Manuals.

END OF SECTION

SECTION 16622

AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.01 WORK INCLUDED

This section specifies the furnishing and installation of automatic transfer switches.

1.02 REFERENCE STANDARDS

I. ANSI/UL 1008 - Automatic Transfer Switches.

II. NEMA ICS 1-109 - Tests.

III. NEMA ICS 2-447 - A-C Automatic Transfer Panels.

1.03 APPLICABLE PROVISIONS

I. Refer to Section 16010, Electrical General Provisions.

1.04 SUBMITTALS

I. Requirements. Refer to Section 16010.

II. Information. Include the following information in submittal:

1- Rated current, voltage and frequency.

2- Number of poles.

3- Symmetrical rms amperes withstand current at 0.2 power factor and at rated voltage.

4- Physical dimensions.

5- NEMA enclosure type.

6- temized list of accessories.

7- Schematic diagram (show wiring and only those components which are part of switch).

8- Show all factory wiring on wiring diagram and clearly indicate all wiring and connections to remote devices which are to be made in the field. (Show only that wiring which pertains to switch and remote devices.)

PART 2 - PRODUCTS

2.01 TYPE

Provide a switch which is electrically operated and mechanically held in each direction, and which is true double-throw with no intermediate position.

2.02 RATING

1. Rating shall be as indicated on the plans.

2.03 OPERATION

I. **General**. The operating transfer time in either direction shall not exceed 10 cycles. Provide all accessories required to accomplish functions as follows.

II. **Sensors**.

1- Provide solid-state sensors to monitor all phases of the normal power source from line to line. The pickup voltage shall be adjustable from 85% to 100% of nominal, and the dropout voltage shall be adjustable from 75% to 98% of pickup value. Set sensors so that transfer to emergency will be initiated upon reduction of normal voltage to 85% of nominal and retransfer to normal will occur when normal voltage is restored to 95 percent of nominal.

2- Provide solid-state sensors to monitor all phases of the emergency power source from line to line. The pickup voltage shall be adjustable from 85% to 100% of nominal and factory set at 90%.

3- Provide solid-state sensors to monitor the frequency of the emergency power source. Set sensor pickup frequency at 90% of normal.

III. **Time Delays**.

1- Provide a time delay to override momentary normal source outages to delay all transfer switch and engine starting signals. The time delay shall be adjustable from 0.5 to 6 seconds and factory set at 1 second.

2- Provide a time delay on retransfer to the normal source. The time delay shall be adjustable from 0 to 30 minutes and factory set at 10 minutes. The time delay shall be automatically bypassed if the emergency source fails and the normal source is available.

3- Provide a time delay on transfer to emergency. The time delay shall be adjustable from 0 to 5 minutes and factory set at 0 unless otherwise indicated.

IV. **Contacts.**

1- Provide a contact that closes when normal source fails, rated 10 amperes, 32 volts d-c.

2- Provide a contact that opens when normal source fails, rated 10 amperes, 32 volts d-c.

3- Provide an auxiliary contact that is closed when the transfer switch is connected to the normal source, rated 10 amperes, 380 volts a-c.

4- Provide an auxiliary contact that is closed when the transfer switch is connected to the emergency source, rated 10 amperes, 380 volts a-c.

V. **Pilot Lights.**

1- Use 10-watt, 220-volt, 10S6 lamps operated at 220 volts.

2- Provide a white signal light to indicate when transfer switch is connected to the normal source.

3- Provide a yellow signal light to indicate when transfer switch is connected to the emergency source.

VI. **Test Switch.** Provide a 2-position, momentary contact, spring return to normal test switch with nameplate ("NORMAL-TEST") to simulate normal source failure.

2.04 MAIN CONTACT PROTECTION

I. Protect main contacts by providing arc barriers on each contact, and on switches rated above 300 amperes by providing separate arcing contacts.

2.05 NEUTRAL BAR

I. Provide a neutral bar with the same capacity as the ampere rating of the switch.

2.06 ACCESSIBILITY

I. Provide a switch on which all parts may be inspected or replaced from the front of the switch without major disassembly, disconnection of power conductors, or removal of the switch from the enclosure.

2.07 ENCLOSURE

A. Provide NEMA 1 switch enclosure suitable for wall mounting.

2.08 PRODUCT DATA

I. Permanently attach wiring diagrams and maintenance instructions on the inside of enclosure door in a mounting designed to hold the data.

2.09 LISTING

A. UL 1008 - Automatic Transfer Switches.

2.10 ACCEPTABLE MANUFACTURERS

I. Not Applicable.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install the transfer switch as shown on the drawings. Make the installation in accordance with manufacturer's instructions.

3.02 PAINTING

I. Restore any marred surfaces to factory finish.

3.03 TESTING

A. Test the switch with the packaged electric generator set in operating condition. Demonstrate to the Engineer that the automatic transfer switch performs all required functions.

END OF SECTION

SECTION 16670
LIGHTNING PROTECTION SYSTEM

PART 1 GENERAL

1.01 SCOPE

A. Provide and install a complete lightning protection system as indicated on the drawings and as specified.

B. The system shall comprise of air terminal network, down conductors, test clamps, and earth termination.

1.02 REFERENCE STANDARDS

A. National Electric Code (NEC)

B. Jordan Code of Practice.

C. British standards.

1.03 SUBMITTALS

A. Refere to section 16010 – Electrical General Provision.

B. Manufacturer's product data, technical literature and wiring diagrams.

C. Shop drawings, including cut sheets of each component and each material utilized in the installation fo the system.

PART 2 PRODUCTS

2.01 AIR TERMINATION

A. Conductors of earth terminals networks shall be of 20 x 3 mm copper unless otherwise specified or required by code and fastened by means of single fixing polypropylene clamps.

2.02 DOWN CONDUCTORS

A. The down conductor shall be, installed in PVC conduit inside the walls, of tinned red copper strip, 20 mm wide x 2 mm thick. If it is impossible to attach the copper strip, a copper cable with a minimum cross section of 70 mm sq., or tinned copper flexible braid 30x3 mm can be utilized. Utilizing a copper strip under lead sheath or PVC must be reserved for down loads installed in particularly corrosive atmosphere. Annealed or zinc plated round steel bars is not permitted.

B. Joints to the air terminal system should be riveted at minimum of 4 points.

C. Joints in down conductors is not permitted.

D. Where down conductors are installed in common ducts, all metal works within the duct shall be bonded to the lightning protection system at the top and the bottom of the runs.

E. All fasteners shal lbe secured to concrete block work by means of brass wool screws and white metal raw plugs.

F. A combination strip and rod conductors, can be used as all or part of the down coductor system providing that they are appropriately connected to the air and earth termination networks, and are known to offer good electrical conductivity. Using "shielded" coaxial cables as down conductors is not permitted.

G. Down conductor systems should take the most direct route from the air termination network to the earth termination network. Ideally they should be symmetrically installed around the outside walls of the structure starting from the corners. Routing to avoid side-flashing should always be given particular attention.

H. Down conductors should be positioned no more than 20 m apart around the perimeter at roof or groung level, whichever is the greater. If the structure is over 20 m height, then the spacing is reduced to every 10 m or part thereof.

I. The length of the conductor forming the loop should not exceed eight times the width of the open side of the loop.

2.03 GROUNDING

A. **Types of earth termination networks.**

1- **Deep Driven Earth Electrode.**

A soil resistivity survey indicating lower resistivity at greater depths will make the deep driven 19 mm2 earth electrode a logical choice.

2- **Parallel Earth Rod Electrodes.**

Where ground conditions make deep driving of earth rods impossible, a matrix arrangement of rods coupled to one another by conductors can be used. If possible, the earth rods must be spaced at least equal to their driven depth.

3- **Radial Strip Electrodes.**

Ground that has one meter depth of soild before encountering bedrock will best be suited to a buried radial electrode. Install the system below the area that is subject to seasonal weather changes.

B. **Testing Grounding System.**

1- An earth electrode should be connected to each down conductor with a test link incorporated into every down conductor path.

With the test link removed and without any bonding to other services, etc. the earth resistance of each individual earth electrode should be measured. The resistance, in ohms, should not exceed ten times the number of down conductors on the structure. For example,

if there are fifteen down conductors equally spaced around building, then the resistance fo each electrode with the test link removed should not exceed 10x15 = 150 ohms.

2- With the test links replaced the resistance to earth of the complete lightning protection system is measured at any point on the system. The reading from this test should not exceed ten ohms. This is still without any bonding to other services.

2.04 BONDING

A. All exposed metal work on or around the structure msut be bonded to the lightning protection system if side-flashing is to be avoided.

Any metal work connected to the lightning network shall not be connected to the main earth busbar.

Aluminium or copper metal lightning system may be used but not both into one system.

PART 3- EXECUTION

3.01 INSTALLATION

A. The routing of the down conductors must be as straight as possible, avoiding all sharp bends or potential backup. The curve radius of a section of the lead running around an abstacle shall not be less than 200 mm.

B. The external metal mass located less than one meter from the down conductor must be electrically connected to these leads (connection by riveting at 4 places) with conductors of the same cross section as the strip itself.

C. The lightning down conductors must include a control junction box or a cut-off bar, in order to allow measurement of the grounding system resistance and of the down conductor electrical continuity. The control junction will be located 2 meters above ground level in order to be accessible only when measurements are made. The control junction box shall not change or interfere with the architectural aspect.

D. The liaison between the down conductor and the grounding system and the control junction must be made by riveting at 4 places. After any check of the installation it is necessary to verify that the connections are correct.

E. The strip will be protected between the control junction and the ground by a PVC pipe inside the wall, this PVC pipe is two meter high from above finished floor.

F. When installing the grounding system, care should be exercised to make sure that it directed towards the outside of the building, and as distant as possible from the building. The earthing system should be at least 3 meters from any burried electrical conduit.

G. A separate grounding system shall be provided to the fuel tank and shall comply with the local codes and standards and as per drawings.

3.02 TESTING AND COMMISIONING

A. All tests requreid by local codes and regulations shall be carried out by the Contractor.

B. Tests on ground continuity as mentioned in the above rules and regulations shall be carried out by the contractor on completed installation.

C. The expenses for the above tests shall be carried out by the Contractor.

D. All tests must be carried out in the presence of the Engineer or the person appointed for this purpose, but the Contractor alone will be responsible to the authorities as to the installation's compliance with rules and regulations.

E. The Contractor shall provide precise instruments and all labor for the testing. Test results shall be submitted to the Engineer withing 14 days of the test, and the Contractor shall issue the Certificate upon completion, as required under the above mentioned regulations.

F. Any defects, faults or omissions of the installations made appartent by such test, shall be corrected by the Contractor at his own expense.

G. Final tests to be carried out inte presence of the Engineer and to start upon the completion of the work and the contractor must submit to the Engineer a detailed test procedure and time schedule for the test.

END OF SECTION