

Design Standard

Emergency Generator Systems

This standard was revised on December 20, 2017, and the latest changes are underlined. Please refer to Part 6 of this standard for full revision history.

Detailed specifications follow.

PART 1 - GENERAL

- 1.01** This specification covers requirements for a complete and operable Emergency/Standby electric Generating system, including all devices and equipment specified herein, shown on the drawings, and/or required for the service. Materials and equipment shall be new, and delivered to the job site completely wired, tested and ready for installation. The system shall include the following:
- A. Provide complete factory assembled generator set equipment with digital (microprocessor-based) electronic generator set controls, digital governor, and digital voltage regulator. Outdoor generator shall be housed in a weatherproof enclosure.
 - B. Provide factory test, startup by a supplier authorized by the equipment manufacturer(s), and on-site testing of the system.
 - C. The generator set manufacturer shall warrant all equipment provided under this section, whether or not is manufactured by the generator set manufacturer, so that there is one source for warranty and product service. Technicians specifically trained and certified by the manufacturer to support the product and employed by the generator set supplier shall service the generator sets.
 - D. Drawings and General provisions of Contract, including General and Supplementary Conditions, and Division 1 specification sections, apply to this and the other sections of Division 16. - Code for Safety to Life from fire in Buildings and Structures.
 - E. Mounted and loose accessories, including skid mounted 24 hour (minimum) fuel tank at full load, batteries and battery charger, remote annunciators, exhaust mufflers, control devices, and other equipment as specified herein.
 - F. Other components, accessories, parts, tests, documents, and services as needed to meet the performance requirements of this specification.
 - G. The manufacturer shall insure that the Owner will be able to obtain any required Air Quality Management District, AQMD permits for the emergency standby system.



- H. The generator system and the enclosure shall be selected and the installation made in a manner to minimize operating noise levels as much as possible and remain under the maximum dB levels as dictated by the local authority having jurisdiction. Consult with specifying engineer if special acoustic housing is required.
- I. The alternate power source can supply emergency loads as well as other loads. However, the emergency system transfer switch is limited to supplying emergency loads. Legally required standby loads or optional standby loads require separate transfer switches.

1.02 CODES AND STANDARDS

- A. The generator set installation and on-site testing shall conform to the requirements of the following codes and standards, as applicable. The generator set shall include necessary features to meet the requirements of these standards:
 - 1. CSA 282, 1989 Emergency Electrical Power Supply for Buildings
 - 2. IEEE446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
 - 3. NFPA37 – Installation and use of stationary combustion engines and gas turbines
 - 4. ANSI/NEMA MG1 Motors and Generators and MG2 Safety and Use of Electric Motors and Generators
 - 5. NFPA70 – National Electrical Code: Equipment shall be suitable for use in systems in compliance to Article 700, 701, and 702
 - 6. NFPA99 – Essential Electrical Systems for Health Care Facilities
 - 7. NFPA 101 - Code for Safety to Life from fire in Buildings and Structure
 - 8. NFPA 110 - System Performance for Level One installation
 - 9. NFPA110 – Emergency and Standby Power Systems. The generator set shall meet all requirements for Level 1 systems. Level 1 prototype tests required by this standard shall have been performed on a complete and functional unit, component level type tests will not substitute for this requirement.
- B. The generator set and supplied accessories shall meet the requirements of the following standards:
 - 1. NEMA MG1. Alternator shall comply with the requirements of the current version this standard as they apply to AC alternators.
 - 2. UL142 – Sub-base Tanks
 - 3. UL1236 – Battery Chargers



4. UL2200. The generator set shall be listed to UL2200 or submit to an independent third party certification process to verify compliance as installed.
 5. NEMA Standard Publication 250 – Enclosures for Electrical Equipment
- C. The control system for the generator set shall comply with the following requirements.
1. CSA C22.2, No. 14 – M91 Industrial Control Equipment.
 2. EN50082-2, Electromagnetic Compatibility – Generic Immunity Requirements, Part 2: Industrial.
 3. EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
 4. FCC Part 15, Subpart B.
 5. IEC8528 part 4. Control Systems for Generator Sets
 6. IEC Std 801.2, 801.3, and 801.5 for susceptibility, conducted, and radiated electromagnetic emissions.
 7. UL508. The entire control system of the generator set shall be UL508 listed and labeled.
- D. The generator set manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.
- E. Local Code Compliance – Comply with all applicable local code requirements of the authority having jurisdiction.

1.03 SUBMITTALS

The following information shall be submitted for this project:

- A. A complete review of this specification, noting for each paragraph whether or not the proposed equipment complies with the project specifications, or deviates in some fashion. For each deviation, a justification for that deviation must be given.
- B. Outline drawings of the equipment showing overall dimensions, power and control wiring entrance locations, breaker sizes and locations, lug sizes, and front panel drawings showing all devices to be provided. Each device shall be referenced to a material list with a complete description for the device. Complete details of the proposed enclosure shall be included.
- C. Estimated fuel consumption at rated load.
- D. Interconnection detail drawing showing all related field control and power connections in the entire emergency / standby system. Differentiate between portions of wiring that are manufacturer installed and portions that are field installed.



- E. Literature, describing in detail, the equipment proposed, and all possible operating modes.
- F. Complete test specification detailing the testing procedure to be used to verify the performance of the equipment provided.
- G. The manufacturer shall provide at least two complete set of operation manuals for the proposed equipment, at the time of the submittal for the engineer's review and approval.
- H. Provide a list and separate price for the maintenance tools and spare parts required to maintain the generating set.
- I. Schedule indicating the system delivery date, submission date for the shop drawings, installation drawings, Factory and Site Acceptance Test Procedures, and O&M manuals.
- J. Upon completion of the onsite testing, a complete set of "as built" drawings shall be furnished for the emergency system, consisting of the following.
 - 1. Equipment outline, showing front and side plan views, electrical power one line diagram, conduit entrances, and equipment ratings.
 - 2. Schematic & Wiring drawings.
 - 3. Interconnection wiring diagram, showing all field interconnections between generator set, panelboards, and other remote devices (such as transfer switches if applicable, annunciators, and day tanks).
 - 4. Material list cross-referenced to schematics for component identification.
 - 5. Narrative sequence of operation description, detailing all possible operating modes.
 - a. All equipment drawings shall specifically show the interface between the automatic transfer switches, generator set, and remote devices. Standard or typical drawings are not acceptable.
 - b. Operator's manuals shall be provided for the emergency power system which include all the information noted above, plus troubleshooting guidelines, spare parts data, final test certificates and maintenance instructions.
 - c. Operator's manuals shall be specific to the project. Standard or typical, pre-printed manuals will not be acceptable.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. The emergency standby electrical generating system equipment shall be the standard of a single manufacturer. It shall be factory-built, tested and shipped by this single manufacturer. Subject to compliance with requirements, provide products by the following:



1. Caterpillar
 2. Stewart & Stephenson¹
 3. Kohler
- B. The manufacturer shall have a minimum ten years of successful operating experience with the rating of the equipment being proposed.
- C. Technical Support: The manufacturer shall provide factory-trained service and parts support through a factory authorized distributor or dealer that is regularly doing business in the area of the installation.
- D. Single Supplier: The supplier shall be the system manufacturer's authorized local representative, who shall provide initial start-up services and be responsible for conducting field acceptance testing. The supplier shall have 24-hour service availability. The supplier shall have factory-trained service technicians who are qualified to isolate and correct any typical malfunction of the engine, generator, voltage regulator system control, fuel day tank system, and implement repair.

2.02 PRODUCT SPECIFICATION

A. Diesel Engine-Generator Set

The outdoor type AC engine-generator set shall be rated by the manufacturer for continuous standby operation as specified by the following rating:

1. Ratings:

The generator set shall operate at 1800 rpm and at a voltage of:
_____ Volts AC, Three phase, _____-wire, _____
hertz.

The generator set shall be rated at _____ kW, _____ kVA
at 0.8 PF, _____ rating, based on site conditions of: Altitude 400ft.,
ambient temperatures up to 120 degrees F

2. Performance:

- a. The generator set manufacturer shall verify the diesel engine is capable of driving the generator with all accessories in place and operating, at the generator set kW rating.
- b. The generator set manufacturer shall verify the diesel engine is capable of driving the generator with all accessories in place and operating, at the generator set kW rating.
- c. Voltage regulation shall be plus or minus 0.5 percent for any constant load between no load and rated load for both parallel and non-parallel applications. Random Voltage Variation: the cyclic variations in RMS voltage shall not exceed 0.5% of rated voltage for constant loads from



- no load to rated load, with constant ambient and operating temperature.
- d. Frequency regulation shall be isochronous from steady state no load to steady state rated load. Random Frequency Variation: speed variations for constant loads from no load to rated load shall not exceed 0.25% of rated speed, with constant ambient and operating temperature.
 - e. The alternator shall produce a clean AC voltage waveform, with not more than 5% total harmonic distortion at full linear load, when measured from line to neutral, and with not more than 3% in any single harmonic, and no 3rd order harmonics or their multiples. Balanced Telephone Interference Factor (TIF) shall not exceed 50 per NEMA MG1-22.43.
 - f. The diesel engine-generator set shall be capable of picking up 100% of nameplate kW and pf in one step with the engine-generator set at the specified operating temperature, in accordance with NFPA Standard 100, Paragraph 5-13.2.6.
 - g. For parallel generators: The generator set shall share real and reactive load proportionally within plus or minus 3% with all other generator sets in the system.
 - h. For parallel generators: The time required to automatically start, accelerate to rated speed and voltage, synchronize and parallel all generator sets to the system bus on a normal power failure shall not exceed 15 seconds.
 - i. Motor starting capability shall be a minimum of 50% of rated kVA. The generator set shall be capable of sustaining a minimum of 90% of rated no load voltage with the specified kVA load at near zero power factor applied to the generator set.
 - j. The generator set shall be certified by the engine manufacturer to be suitable for use at the installed location and rating, and shall meet all applicable exhaust emission requirements at the time of commissioning.
 - k. The generator shall be capable of start-up and accepting rated load within 10 seconds.
3. Construction
- a. The engine-generator set shall be mounted on a heavy duty steel base to maintain proper alignment between components, and each set shall incorporate vibration isolators of the type and quantity as specified by the set manufacturer, whether mounted internally or externally.



- b. All switches, lamps, and meters in the control system shall be oil tight and dust tight. There shall be no exposed points in the control (with the door open) that operate in excess of 50 volts.

4. Connections

- a. The generator set load connections shall be composed of tin plated copper bus bars, drilled to accept mechanical or compression terminations of the number and type as shown on the drawings.
- b. Power connections to auxiliary devices shall be made at the devices, with required protection located at a wall-mounted common distribution panel.
- c. Generator set control interfaces to other system components shall be made on a common, permanently labeled terminal block assembly.

B. AC GENERATOR, REGULATOR AND EXCITER

The AC generator, exciter and voltage regulator shall be designed and manufactured by the engine-generator set manufacturer as a complete generator system.

1. The AC generator shall be synchronous, four pole, revolving field, drip proof construction, single pre-lubricated sealed bearing, air cooled by a direct drive centrifugal blower fan, and directly connected to the engine with flexible drive disc(s).
 - a. The armature shall have skewed laminations of insulated electrical grade steel, two-thirds pitch windings.
 - b. The rotor shall have amortisseur (damper) windings; layer wound mechanically wedged winding construction. The rotor shall be dynamically balanced.
 - c. The exciter shall be brushless, three phase, with full wave silicon diodes mounted on the rotating shaft and a surge suppressor connected in parallel with the field winding. Field discharge resistors shall not be acceptable. Systems using three-wire solid-state devices (such as SCRs or transistors) mounted on the rotor shaft shall not be acceptable.
2. AC output leads shall be brought out to field connection bus bars accessible through removable plates on either side of a sheet metal output box.
3. All insulation system components shall meet NEMA MG1 standard temperature limits for Class H insulation system. Actual temperature rise measured by resistance method at full load shall not exceed 105 degrees



Centigrade to provide additional allowance for internal hot spots and superior generator performance. The main generator and exciter insulation systems must be suitably impregnated for operation in severe environments for resistance to sand, salt and sea spray.

4. A permanent magnet generator (PMG) shall provide excitation power to the automatic voltage regulator for immunity from voltage distortion caused by nonlinear SCR controlled loads on the generator. The PMG shall sustain main field excitation power for optimum motor starting and to sustain short circuit current for selective operation and coordination of system overcurrent devices. The PMG and controls shall be capable of sustaining and regulating current supplied to a single phase or three phase fault at approximately 300% of rated current for not more than 10 seconds.
5. The automatic voltage regulator shall be temperature compensated, solid-state design and include overvoltage and over excitation protection functions. The voltage regulator shall be equipped with three phase RMS sensing.
6. The regulator shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. Overvoltage protection shall sense the AC generator output voltage and in the event of regulator failure or loss of reference, shut down regulator output on a sustained overvoltage of one (1) second duration. Both overvoltage and over excitation protection shutdowns shall be latched, requiring the AC generator to be stopped for reset.
7. The generator shall be capable of operating with a load exceeding 35% total current harmonic distortion. The manufacturer shall provide certification of generator harmonics tolerance. The most significant harmonics are the fifth, seventh, eleventh and thirteenth.
8. The subtransient reactance of the alternator shall not exceed 15 percent, based on the standby rating of the generator set.
9. The alternator shall be capable of operation with at least 0.15 per unit reverse kVAR.
10. 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.

C. ENGINE GENERATOR SET CONTROL

The generator set shall be provided with a microprocessor-based control system that is designed to provide automatic starting, monitoring, and control functions for the generator set. The control system shall also be designed to allow local and remote monitoring and control of the generator set.



The control shall be mounted on the generator set. The control shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered. The generator set mounted control shall include the following features and functions:

1. Control Switches
 - a. Mode Select Switch: The mode select switch shall initiate the following control modes. When in the RUN or Manual position the generator set shall start, and accelerate to rated speed and voltage as directed by the operator. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.
 - b. EMERGENCY STOP switch: Switch shall be Red "mushroom head" push button. Depressing the emergency stop switch shall cause the generator set to immediately shut down, and be locked out from automatic restarting.
 - c. RESET switch: The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.
 - d. PANEL LAMP switch: Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be switched off 10 minutes after the switch is depressed, or after the switch is depressed a second time.
2. Generator Set AC Output Metering. The generator set shall be provided with a metering set including the following features and functions:
 - a. Analog voltmeter, ammeter, frequency meter, and kilowatt (KW) meter. Voltmeter and ammeter shall display all three phases. Ammeter and KW meter scales shall be color coded in the following fashion: readings from 0 90% of generator set standby rating: green; readings from 90 100% of standby rating: amber; readings in excess of 100%: red.
 - b. Digital metering set, 1% accuracy, to indicate generator RMS voltage and current, frequency, output current, output KW, KW hours, and power factor. Generator output voltage shall be available in line to line and line to neutral voltages, and shall display all three phase voltages (line to neutral or line to line) simultaneously.
 - c. Both analog and digital metering are required. The analog and digital metering equipment shall be driven by a single microprocessor, to provide consistent readings and performance.



3. Generator Set Alarm and Status Display
 - a. The generator set shall be provided with alarm and status indicating lamps to indicate non automatic generator status, and existing warning and shutdown conditions. The lamps shall be high intensity LED type. The lamp condition shall be clearly apparent under bright room lighting conditions. The generator set control shall indicate the existence of the following alarm and shutdown conditions on an alphanumeric digital display panel:
 - low oil pressure (alarm)
 - low oil pressure (shutdown)
 - oil pressure sender failure (alarm)
 - low coolant temperature (alarm)
 - high coolant temperature (alarm)
 - high coolant temperature (shutdown)
 - engine temperature sender failure (alarm)
 - low coolant level (alarm or shutdown--selectable)
 - fail to crank (shutdown)
 - fail to start/overcrank (shutdown)
 - overspeed (shutdown)
 - low DC voltage (alarm)
 - high DC voltage (alarm)
 - weak battery (alarm)
 - low fuel-daytank (alarm)
 - high AC voltage (shutdown)
 - low AC voltage (shutdown)
 - under frequency (shutdown)
 - over current (warning)
 - over current (shutdown)
 - short circuit (shutdown)
 - ground fault (alarm)



over load (alarm)

emergency stop (shutdown)

In addition, the control shall display all warning and shutdown message produced by the electronic engine control module.

- b. Provisions shall be made for indication of four customer specified alarm or shutdown conditions. Labeling of the customer-specified alarm or shutdown conditions shall be of the same type and quality as the above specified conditions. The non automatic indicating lamp shall be red, and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.

4. Engine Status Monitoring.

- a. The following information shall be available from a digital status panel on the generator set control:

engine oil pressure (psi or kPA)

engine coolant temperature (degrees F or C)

engine speed (rpm)

number of hours of operation (hours)

number of start attempts

battery voltage (DC volts)

- b. The control system shall also incorporate a data logging and display provision to allow logging of the last 10 warning or shutdown indications on the generator set, as well as total time of operation at various loads, as a percent of the standby rating of the generator set.

5. Engine Control Functions.

- a. The control system provided shall include a cycle cranking system, which allows for user selected crank time, rest time, and # of cycles. Initial settings shall be for 3 cranking periods of 15 seconds each, with 15-second rest period between cranking periods. Two means of cranking termination shall be provided, one as a backup to the other. Failure to start after three cranking cycles (75 seconds) shall shut down and lockout the engine and visually indicate an overcrank shutdown on the panel.

- b. The control system shall include an idle mode control, which allows the engine to run in idle mode in the RUN position only. In this mode, the alternator excitation system shall be disabled.

- c. The control system shall include an engine governor control, which functions to provide steady state frequency regulation as noted



elsewhere in this specification. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting. The governor control shall be suitable for use in paralleling applications without component changes.

- d. The control system shall include time delay start (adjustable 0 300 seconds) and time delay stop (adjustable 0 600 seconds) functions.
 - e. The control system shall include sender failure monitoring logic for speed sensing, oil pressure, and engine temperature which is capable of discriminating between failed sender or wiring components, and an actual failure conditions.
 - f. For paralleled generators: The control system shall include all interfaces necessary for proper operation with the paralleling equipment provided under this contract. The generator set supplier shall be responsible for complete compliance to all specification requirements for both the generator set and the paralleling equipment.
6. Alternator Control Functions:
- a. The generator set shall include an automatic digital voltage regulation system that is matched and prototype tested by the engine manufacturer with the governing system provided. It shall be immune from mis-operation due to load induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The voltage regulator shall be full wave rectified design. The voltage regulation system shall be equipped with three phase RMS sensing and shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. The system shall include a torque matching characteristic, which shall reduce output voltage in proportion to frequency below a threshold of [58 59] HZ. The voltage regulator shall include adjustments for gain, damping, and frequency roll off. Adjustments shall be broad range, and made via digital raise-lower switches, with an alphanumeric LED readout to indicate setting level. Rotary potentiometers or for system adjustments are not acceptable.
 - b. Controls shall be provided to monitor the output current of the generator set and initiate an alarm (over current warning) when load current exceeds 110% of the rated current of the generator set on any phase for more than 60 seconds. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (over current shutdown). The protective functions provided shall be in compliance to the requirements of NFPA70 article 445. Performance of this function shall be 3rd party certified.



- c. Controls shall be provided to individually monitor all three phases of the output current for short circuit conditions. The control/protection system shall monitor the current level and voltage. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (short circuit shutdown). The protective functions provided shall be in compliance to the requirements of NFPA70 article 445. Performance of this function shall be 3rd party certified.
 - d. Controls shall be provided to monitor the KW load on the generator set, and initiate an alarm condition (over load) when total load on the generator set exceeds the generator set rating for in excess of 5 seconds. Controls shall include a load shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.
 - e. A line to neutral AC over/under voltage monitoring system that responds only to true RMS voltage conditions shall be provided. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.
 - f. The control System shall include a ground fault monitoring relay. The relay shall be adjustable from 3.8 1200 amps, and include adjustable time delay of 0 10.0 seconds. The relay shall be for indication only, and not trip or shut down the generator set. Note bonding and grounding requirements for the generator set, and provide relay that will function correctly in system as installed.
 - g. For paralleling applications: The voltage regulation system shall include provisions for reactive load sharing and electronic voltage matching for paralleling applications. Motorized voltage adjust pot is not acceptable for voltage matching.
7. The generator set shall be provided with a network communication module to allow MODBUS over Ethernet and RS485/232 communication with the generator set control by remote devices. The control shall communicate all engine and alternator data, and allow starting and stopping of the generator set via the network in both test and emergency modes.
 - a. Control Interfaces for Remote Monitoring:
 - 1) All control and interconnection points from the generator set to remote components shall be brought to a separate connection



box. No field connections shall be made in the control enclosure or in the AC power output enclosure. Provide the following features in the control system:

- 2) Form "C" dry common alarm contact set rated 2A @ 30VDC to indicate existence of any alarm or shutdown condition on the generator set.
- 3) One set of contacts rated 2A @ 30VDC to indicate generator set is ready to load. The contacts shall operate when voltage and frequency are greater than 90% of rated condition.
- 4) A fused 10 amp switched 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit whenever the generator set is running.
- 5) A fused 20 amp 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit at all times from the engine starting/control batteries.

D. ENGINE

The diesel engine shall be designed specifically for generator set duty. The engine shall be four cycle, fan cooled, #2 diesel fueled, direct injection, with forged steel crankshaft and connecting rods. The cylinder block shall be cast iron with replaceable wet liners, and have four valves per cylinder. Design shall be turbocharged and after-cooled where required by the generator set manufacturer. The horsepower rating of the engine at its minimum tolerance level shall be sufficient to drive the alternator and all connected accessories.

1. An electronic governor; consisting of a magnetic pickup speed sensor, adjustable electronic control, and an electric actuator mounted integrally with the fuel pump, shall provide automatic engine-generator set frequency regulation adjustable from isochronous to 5% droop. The control system shall actively control the fuel rate and excitation as appropriate to the state of the generator set. Fuel rate shall be regulated as a function of starting, accelerating to start disconnect speed, accelerating to rated speed, and operating in various isochronous or parallel states.
2. The engine shall be cooled by a skid-mounted closed loop radiator system including belt-driven pusher fan, coolant pump and thermostat temperature control. The cooling system shall be rated for full rated load operation in ambient conditions as specified in the attached Data Sheet. The cooling capability of the generator set shall be demonstrated by prototype tests on a representative generator set model. The generator set manufacturer will



conduct these tests; calculated data from the radiator manufacturer only is not sufficient.

3. Skid mounted radiator and cooling system rated for full load operation in 120 degrees F ambient as measured at the generator air inlet, based on 0.5 in H₂O external static head. Radiator shall be sized based on a core temperature which is 20F higher than the rated operation temperature, or prototype tested to verify cooling performance of the engine/radiator/fan operation in a controlled environment.

Radiator shall be provided with a duct adapter flange. The cooling system shall be filled with a 50/50-ethylene glycol/water mixture by the equipment manufacturer. Rotating parts shall be guarded against accidental contact.

E. ENGINE ACCESSORY AND FEATURES

The engine generator set shall include the engine accessories as follows

1. An electric starter(s) capable of three complete cranking cycles without overheating before overcrank shutdown (75 seconds).
2. Positive displacement, mechanical, full pressure, lubrication oil pump. Full flow lubrication oil filters with replaceable spin-on canister elements and dipstick oil indicator.
3. Engine driven, mechanical, positive displacement, redundant fuel pumps. Primary and secondary fuel filters with replaceable spin-on canister elements.
4. Replaceable dry element air cleaner with restriction indicator.
5. Flexible fuel lines, supply and return. A means for hand priming the engine shall also be provided.
6. Engine mounted battery charging alternator, 45 ampere minimum, and solid-state voltage regulator.

F. BASE

The engine-generator set shall be mounted on a heavy duty steel base to maintain proper alignment between components. The engine-generator set shall incorporate a battery tray with battery hold down clamps within the base rails. Provisions for stub up of electrical and fuel connections shall be within the footprint of the generator set base rails.



Provide vibration isolators, spring/pad type, quantity as recommended by the generator set manufacturer. Isolators shall include seismic restraints if required by site location.

G. GENERATOR SET AUXILIARY EQUIPMENT

1. Engine mounted thermostatically controlled, coolant and engine heater(s). The heater(s) shall be sized according to site conditions. The contractor shall provide a branch circuit to the heater. The heater shall be U. L. 499 listed and labeled.
 - a. The coolant heater shall be installed on the engine with high temperature silicone hose connections. Steel tubing shall be used for connections into the engine coolant system wherever the length of pipe run exceeds 12 inches. The coolant heater installation shall be specifically designed to provide proper venting of the system. The coolant heaters shall be installed using quick disconnect couplers to isolate the heater for replacement of the heater element. The quick disconnect/automatic sealing couplers shall allow the heater element to be replaced without draining the engine cooling system or significant coolant loss.
 - b. The coolant heater shall be provided with a 24VDC thermostat, installed at the engine thermostat housing. An AC power connection box shall be provided for a single AC power connection to the coolant heater system.
 - c. The coolant heater(s) shall be sized as recommended by the engine manufacturer to warm the engine to a minimum of 100F (40C) in a 40F ambient, in compliance with NFPA110 requirements, or the temperature required for starting and load pickup requirements of this specification.
2. Exhaust muffler(s) shall be provided for each engine, size and type as recommended by the generator set manufacturer. The mufflers shall be critical grade. The supplier shall mount the mufflers so the engine does not support their weight.
 - a. The equipment supplier shall provide stainless steel seamless flexible exhaust connections for installation as required for connection between the engine exhaust manifolds and exhaust line in compliance with applicable codes and standards.



- b. The supplier shall provide an exhaust system condensation trap with manual drain valve to trap and drain off exhaust condensation and to prevent condensation from entering the engine.
- c. The supplier shall provide a suitable rain cap at the stack outlet with all necessary flanges and fittings for proper installation.
- d. The supplier shall install all exhaust components as shown on the drawings, if applicable, and as required to comply with NFPA 37 and local codes and regulations. Components shall be sized to assure full load operation without excessive back pressure when installed as shown on the drawings, if applicable. Make provisions as required for pipe expansion and contraction. Also, provide covering for all indoor exhaust piping with a proper insulation material in a manner not to interfere with flexible exhaust connections.

H. SYSTEM AUXILIARIES

- 1. Starting and Control Batteries: 12VDC or 24VDC starting batteries sized as recommended by the generator set manufacturer, shall be supplied for the generator set with battery cables and connectors. The batteries shall be capable of performing the crank/rest cycles at temperatures of 10 degree F.
- 2. Provide 10 amp battery charger for generator set starting batteries.
 - a. Chargers shall be UL 1236-BBHH listed and CSA or CUL certified for use in emergency applications.
 - b. The charger shall be compliant with UL991 requirements for vibration resistance.
 - c. The charger shall comply with the requirements of EN61000-4-5 for voltage surge resistance; EN50082-2 for immunity; EN61000-4-2 for ESD; EN61000-4-3 for radiated immunity; ANSI/IEEE C62.41 category B and IN61000-4-4 for electrically fast transient; EN61000-4-6 for conducted emissions; and FCC Part 15 Class A for radiated emissions.
 - d. The charger shall be capable of charging a fully discharged battery without damage to the charger. It shall be capable of returning a fully discharged battery to fully charged condition within 24 hours. The charger shall be UL-labeled with the maximum battery amp-hour rating that can be recharged within 24 hours.
 - e. The charger shall incorporate a 4-state charging algorithm, to provide trickle charge rate to restore fully discharged batteries, a bulk charge



rate to provide fastest possible recharge after normal discharge, an absorption state to return the battery to 100 percent of charge, and a float stage to maintain a fully charge battery and supply battery loads when the generator set is not operating. In addition, the charger shall include an equalization timer. Charge rates shall be temperature compensated based on the temperature directly sensed at the battery.

- f. The DC output voltage regulation shall be within plus or minus 1%. The DC output ripple current shall not exceed 1 amp at rated output current level.
- g. The charger shall include the following features:
 - 1) Two-line alphanumeric display with programming keys to allow display of DC output ammeter and voltmeters (5% accuracy or better), display alarm messages, and perform programming.
 - 2) LED indicating lamp(s) to indicating normal charging condition (green), equalize charge state (amber), and fault condition (red).
 - 3) AC input overcurrent, over voltage, and undervoltage protection.
 - 4) DC output overcurrent protection.
 - 5) Alarm output relay; individual form C contacts rated at 4 amps, 120 VAC, 30 VDC for remote indication of
 - 6) Corrosion resistant aluminum enclosure.
3. A battery monitoring system shall be provided which initiates alarms when the DC control and starting voltage is less than 25VDC or more than 32 VDC. During engine cranking (starter engaged), the low voltage limit shall be disabled, and if DC voltage drops to less than 14.4 volts for more than two seconds a "weak battery" alarm shall be initiated.
4. Grounding Pads: Two non-corrosive, stainless steel grounding pads shall be welded to the alternator. The pads shall be located diagonally opposite one another.
5. Remote Annunciator:
 - a. Provide and install a 20-light LED type remote alarm annunciator with horn, located as shown on the drawings or in a location that can be conveniently monitored by facility personnel. The remote annunciator shall provide all the audible and visual alarms called for by NFPA Standard 110 for level 1 systems; and in addition shall provide indications for high battery voltage, low battery voltage, loss of normal



power to the charger. Spare lamps shall be provided to allow future addition of other alarm and status functions to the annunciator.

- b. Provisions for labeling of the annunciator in a fashion consistent with the specified functions shall be provided. Alarm silence and lamp test switch(es) shall be provided. LED lamps shall be replaceable, and indicating lamp color shall be capable of changes needed for specific application requirements. Alarm horn shall be switchable for all annunciation points. Alarm horn (when switched on) shall sound for first fault, and all subsequent faults, regardless of whether first fault has been cleared, in compliance with NFPA110 3-5.6.2.
6. Exhaust Silencer Mounting: The engine-generator supplier shall mount a critical grade silencer inside the enclosure. The silencer and exhaust pipe shall be properly insulated with heat resistant material to prevent damage or impairment to the system or enclosure.
 7. Ductwork: The engine-generator supplier shall install a galvanized air discharge duct, with flexible section between the engine radiator and the exhaust louver.
 8. Fuel Tank: Provide a dual wall sub base fuel storage tank with capacity to run engine at rated load for 24 hours. The tank shall be constructed of corrosion resistant steel and shall be UL142 listed. The equipment, as installed, shall meet all local and regional requirements for above ground tanks.
 - a. The tank shall be made of steel. In applications utilizing daytanks incorporate an integral fuel pump with 20 foot lift. The pump control shall be provided with On/Off/Emergency Run Switch, Test/Reset Switch, AC Circuit Breaker, DC Circuit Breaker, and Indicator lamps:
 - Ready (green) - AC supply & DC control power available.
 - High Fuel (red) - Latching fault, indicates fuel level near overflow, shuts down pump, and closes N/O dry contacts.
 - Low Fuel (red) - Latching fault, indicates pump failure or operating float switch failure, Closes N/O dry contacts.
 - Low Fuel Shutdown (red) - Latching fault, indicates near empty tank, closes N/O contacts which may be used to shutdown generator set to avoid air in the injection system.
 - Overflow to basin (red) - Latching fault, indicates fuel in overflow/rupture basin, shuts down pump, closes N/O dry contacts.
 - Spare (red) - with N/O and N/C dry contacts



Pump Running (green)

- b. Contacts for the noted conditions shall be provided, and rated not less than 2 amps at 30VDC and 0.5 amps at 120VAC.

I. **LOAD BANKS**

In order to comply with NFPA 110 for minimum loading during routine maintenance tests, all generator sets shall be equipped with a permanent load bank, either freestanding or radiator mounted, that is 50% the nameplate kW rating.

1. **(Radiator Mounted)**

- a. Operational ratings and limitations as follows:
 - 1) Capacity: _____ KW (400KW maximum), 1.0 power factor.
 - 2) Voltage: 480V AC, 3- phase, 3- wire.
 - 3) Frequency: 60 Hertz.
 - 4) Load Steps: KW step resolution.
 - 5) Duty Cycle: Continuous.
 - 6) Temp. Rating: 180°F max. air intake temp. 60°-100°F nominal air temp. rise.
 - 7) Airflow Required: Radiator air outflow.
 - 8) Altitude: 5500' (higher, contact Simplex).
 - 9) Control Power: Internal, from generator. 480V AC, single-phase. Fused circuits. Controls operate at 120V via control power transformer circuit.
- b. Principle systems and components as follows:
 - 1) Load Elements: Tubular type, weatherproof, totally enclosed, UL listed.
 - 2) Load Control: Branch circuit magnetic contactors.
 - 3) Element Short Circuit Protection: Branch circuit fuses. Fuses are 200KAIC, 600V, current limiting.
 - 4) Power Wiring: 150°C, insulated, color coded.
 - 5) Power Connection: Barrier type power distribution block with line side compression terminals.
 - 6) Control Wiring: 16AWG, 105°C.



- 7) Overheat Protection: Sensor to detect high exhaust air temp above 300°F. Circuits to disconnect load bank on overtemp. Alarm contacts.
- 8) Enclosure: Type 1, Galvanized Steel Construction, Designed for permanent installation by mounting, (pick: Directly to engine radiator, Within radiator air outflow duct, On inside of wall over radiator air outlet, On outside of wall over radiator air outlet.

c. Load bank control: Local

- 1) Manual
- 2) Control panel with control power on-off push-buttons master load control switch, load step switches, overtemp indicator, normal operation indicator. Internal control circuit and input terminals to dump load bank off-line on opening of remote control contacts.

2. **(Freestanding Load Bank)**

a. Scope

- 1) This specification contains the minimum requirements for the design, manufacture and testing of a UL listed, air-cooled, outdoor weatherproof resistive load bank.
- 2) The load bank is required for periodic exercising and testing of the (standby) emergency power source. The load bank shall be permanently mounted in a weatherproof enclosure, forced air cooled with locally mounted control panel.
- 3) The equipment covered by this specification shall be designed with the latest applicable NEMA, NEC, and ANSI standards.

b. Ratings

- 1) The total capacity of the load bank shall be rated (_____) KW at (_____) Volts, 3-Phase, 3-Wire, 60 Hertz, (_____) Amps per Phase at unity Power Factor and (___) KW minimum load step resolution.
- 2) The load bank shall be designed for continuous duty cycle operation with no limitations. The load bank shall operate in an ambient temperature of -28°C to 49°C (-20°F to 120°F).

c. Material and Construction

- 1) The load bank shall be outdoor weatherproof construction, suitable for installation on a concrete pad or structural base. All exterior fasteners shall be stainless steel. The load bank shall include forklift channels in the base for lifting.



- 2) The load bank shall be constructed of heavy gauge aluminized steel per ASTM A463. Aluminized steel provides superior corrosion protection and extended service life, with a better tolerance to high heat exposure compared to the more common Galvanized steel.
 - 3) The main input load bus, load step relays, fuses and blower/control relays shall be located within the load bank enclosure. A thermostatically controlled heater shall be located within the control section to provide protection to the control devices from the effects of moisture and condensation.
 - 4) Airflow throughout the load bank shall be vertical (>500 kW) or horizontal (<500 kW).
- d. Resistive Load Elements
- 1) Load elements shall be Avtron Helidyne™, helically wound chromium alloy rated to operate at approximately ½ of maximum continuous rating of wire. Elements must be fully supported across the entire length within the air stream by segmented ceramic insulators on stainless steel rods. Element supports shall be designed to prevent a short circuit to adjacent elements or to ground.
 - 2) The overall tolerance of the load bank shall be –0% to +5% KW at rated voltage. A –5%, +5% rating allows the load bank to deliver less than rated KW and shall not be used. The load bank must deliver full rated KW at rated voltage.
- e. Cooling
- 1) The load bank shall be cooled by integral TEFC or TEAO motor(s) which is direct coupled to the cooling fan blade. The fan motor must be electrically protected against overload using a motor overload device and short circuit protected using three (3) current limiting fuses with an interrupting rating of 200K A.I.C.
 - 2) An integral control power transformer shall be provided to supply 120V, 1 phase, 60 Hz to the load banks control and motor starter circuitry. Transformer primary and secondary control circuits shall be fuse protected.
- f. Protective Devices
- 1) A differential pressure switch(s) shall be provided to detect air loss. The switch(s) shall be electrically interlocked with the load application controls to prevent load from being applied if cooling air is not present.



- 2) An over-temperature switch shall be provided to sense the load bank exhaust in each vertical heater case assembly. The switch shall be electrically interlocked with the load application controls to remove load from being applied in the event of an over temperature condition.
 - 3) To provide for major fault protection, branch fuses shall be provided on all three phases of switched load steps above 50KW. Branch fuses shall be current limiting type with an interrupting rating of 200K A.I.C.
 - 4) The exterior of the load bank shall have appropriate warning/caution statements on access panels.
- g. Control Panel
- 1) The control panel shall be a locally mounted panel housed in a NEMA 4 type enclosure. The control panel shall contain the following manual controls:
 - a) Power ON/OFF switch.
 - b) Blower START/STOP pushbuttons.
 - c) Master load ON/OFF switch.
 - d) Load step switches for ON/OFF application of individual load steps.
 - 2) Control panel visual indicators shall be as follows:
 - a) Power ON indication light.
 - b) Blower ON light.
 - c) Blower/Air FAILURE light.
 - d) OVERTEMPERATURE light.
 - 3) A standard remote load dump circuit shall be provided as part of the load bank control circuit. Provisions shall be provided to remove the load bank off-line from the operation of a remote normally closed set of auxiliary contacts from a transfer switch or other device. In the event of the remote contact opening, all load is removed.
- h. Qualifications of Manufacturer.
- 1) The load bank shall be manufactured by a firm regularly engaged in the manufacture of load banks and who can demonstrate at least twenty-five (25) years experience with at least twenty-five (25) installations of load banks similar or equal to the ones specified herein.



- 2) The load bank shall be as manufactured by Simplex or Avtron, no substitutions.

J. Enclosure

1. An outdoor enclosure shall be provided for the engine-generator set. The enclosure shall be sized for the exact unit being installed and include all necessary auxiliary equipment needed for operation of the emergency standby system described herein.
2. Enclosure overall acoustical performance should be XX dB(A) @ XX feet.
3. The enclosure shall be of the welded and bolted design, with all fabricated steel parts conforming to ASTM 569, specification C-1018 and all structural steel conforming to ASTM A36. All parts are to be individually prepped and primed prior to assembly.
4. Roof: The roof shall be of the tapered design for moisture runoff, with 12 gauge steel roof members and 16 gauge steel roof panels. Lifting eyes shall be supplied. The exhaust outlet shall be supplied with a steel ring above the roof line to prevent moisture from entering the enclosure.
5. Walls: The wall shall be a minimum of 14 gauge steel.
6. Base: The base of the enclosure shall be designed for a drop-over installation, and shall include a means for fastening to a concrete slab. The drop-over style shall include a fabricated channel construction perimeter. Provide an alternate grate for a portable enclosure.
7. Louvers: The air openings shall include fixed louvers sized to allow proper air flow. The frames shall be manufactured of 14 gauge steel, the blades 14 gauge steel, and the fronts shall be covered with 14 gauge expanded steel screen.
8. Doors: Adequate doors shall be installed for sufficient access. Single doors shall be a minimum of 30" wide. Double doors shall be a minimum of 60" wide. Doors shall include stainless steel hinges with brass pins, rain rail moldings above all door openings, recessed, keyed, chromed handles with positive locking assemblies, and fully weather-stripped. Doors shall be removable and lockable and have panic hardware.
9. Paint: All seams shall be caulked with body sealer. Enclosure shall be metal prepped, primed with two coats of self-etching primer and finished with two coats of weather grade paint of a color matching owner's requirement. Default color shall be Aggie Power Plant Tan (Sherman Williams SW 6114 Bagel).



PART 3 - OPERATION

3.01 Sequence of Operation

- A. Generator set shall start on receipt of a start signal from remote equipment. The start signal shall be via hardwired connection to the generator set control and a redundant signal over the required network connection.
- B. The generator set shall complete a time delay start period as programmed into the control.
- C. The generator set control shall initiate the starting sequence for the generator set. The starting sequence shall include the following functions:
 1. The control system shall verify that the engine is rotating when the starter is signaled to operate. If the engine does not rotate after two attempts, the control system shall shut down and lock out the generator set, and indicate “fail to crank” shutdown.
 2. The engine shall fire and accelerate as quickly as practical to start disconnect speed. If the engine does not start, it shall complete a cycle cranking process as described elsewhere in this specification. If the engine has not started by the completion of the cycle cranking sequence, it shall be shut down and locked out, and the control system shall indicate “fail to start”.
 3. The engine shall accelerate to rated speed and the alternator to rated voltage. Excitation shall be disabled until the engine has exceeded programmed idle speed, and regulated to prevent over voltage conditions and oscillation as the engine accelerates and the alternator builds to rated voltage.
- D. On reaching rated speed and voltage, the generator set shall operate as dictated by the control system in isochronous, synchronize, load share, load demand, or load govern state.
- E. When all start signals have been removed from the generator set, it shall complete a time delay stop sequence. The duration of the time delay stop period shall be adjustable by the operator.
- F. On completion of the time delay stop period, the generator set control shall switch off the excitation system and shall shut down.
 1. Any start signal received after the time stop sequence has begun shall immediately terminate the stopping sequence and return the generator set to isochronous operation.



PART 4 - EXECUTION

4.01 Testing and Quality Control

- A. To provide proven reliability of the system, three series of tests shall be performed: Prototype Model Tests, Production Model Tests, and Field Tests. The manufacturer shall provide documentation demonstrating satisfactory prototype and production test results.
1. Factory Prototype Model Tests: The electrical 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 110-1985. 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 110-1985, paragraph 3-2.1 through 3-2.1.2 and their accomplishment certified by means of documentation of the tests accompanying submittal data. These tests shall have included:
 - a. Maximum power level (maximum kW).
 - b. Maximum motor starting capacity (maximum KVA) and voltage dip recovery within seven (7) cycles of applied load.
 - c. Structural soundness (Short Circuit and Endurance Test).
 - d. 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 test on a representative prototype unit. The empirical data must include spectrum analysis of the torsional transducer output within the critical speed range of the generator set. Results of this analysis shall be made available on submittal. Calculation based on engine and generator separately are not acceptable.
 - e. Engine-generator cooling air requirements.
 - f. Transient response and steady-state speed control and voltage regulation.
 - g. Generator temperature rise per NEMA MGF1-22.40.
 - h. Harmonic analysis and voltage wave form deviation per MIL-STD-705B, method 601.4.
 - i. Three-phase short-circuit test for mechanical and electrical strength, with system operating at rated volts, amps, power factor, and speed. The 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.



- j. 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.
- k. Endurance testing is required to detect and correct potential electrical and mechanical problems associated with typical operation.

2. 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 is not acceptable, since kilowatt output is affected by the higher generator efficiency at unity power factor, and the KVAR for motor starting and regulation loads varies with power factor. Test shall include:

- a. Single step load pickup per NFPA 10-1985, paragraph 5-13.2.6.
- b. Transient and voltage dip responses and steady state voltage and speed (frequency) checks.
- c. Fuel consumption (No load, 25% load, 50% load, 75% load, and Full load).
- d. Generator temperature rise by resistance method.
- e. The Engineer shall have the option of witnessing these tests. A summary of the test results shall be available for submittal.

3. On Site Field Acceptance System Testing:

The manufacturer of the standby diesel engine generator shall furnish a service engineer or engineers, who is, or are, expert in the installation of the emergency system, and shall make the initial start and complete the field testing of the equipment at the Site. The following are requirements in performing the field test:

- a. The generator controls manufacturer shall provide services of an engineer at the site as requested during the test and during any additional period of time needed to correct any deficiencies to the satisfaction of the Owner and Engineer. Conduct run test at site using certified laboratory recording instruments and maintain hourly written records of tests. The records shall include ampere, voltage and frequency and the engine and generator temperatures.
- b. All tests shall be run consecutively. The engine generator supplier shall furnish all facilities and equipment, including electrical load for load tests, which shall be capable of being switched in 20 kW increments from zero to full load.



- c. The on site testing shall be done only in the presence of the Electrical Engineer, and the Owner or his authorized representative.
- d. Failure of any component or System shall require the component to be replaced or repaired. At the option of the Engineer, the entire system shall be retested.
- e. Provide all necessary testing equipment, cabling for temporary connections and other equipment necessary to complete the testing procedures.
- f. All testing of the equipment shall be conducted at a time scheduled by the Owner. The Owner shall be given two weeks notice before any testing is scheduled. The schedule must be approved by the Owner prior to testing.
- g. The following tests and inspection shall be performed on the engine Generator Assembly at the site:
 - 1) Inspect for physical damage.
 - 2) Compare nameplate rating and connection specifications and single line diagram.
 - 3) Inspect for proper anchorage and grounding. Verify cooling and fuel system integrity.
 - 4) Initial equipment start-up and operation will completed by the manufacturer's representative.
 - 5) Protective relay devices shall be tested to determine proper operation.
 - 6) Engine shutdown features shall be function tested under the following conditions:

Low oil pressure, Over-temperature, Over-speed, Other features as applicable
 - 7) Perform voltage and frequency transients' test for 100% and 50% load step addition and subtraction showing compliance with these specifications. Use an oscillograph chart recording instrument pr manufacturer's service software to record the test results.
 - 8) Perform resistive load bank test at one hundred percent (100%) nameplate rating. Loading shall be:

25% rated for 30 minutes
50% rated for 30 minutes
75% rated for 30 minutes
100% rated for 4 hours



h. Test Values

- 1) Load test results shall be in accordance with manufacturer's specifications.

PART 5 - OTHER REQUIREMENTS

5.01 Training

- A. The equipment supplier shall provide training for the facility operating personnel covering operation and maintenance of the equipment provided. The training program shall be not less than 4 hours in duration and the class size shall be limited to 5 persons. Training date shall be coordinated with the OWNER.

5.02 Warranty

- A. The manufacturer shall warranty all products against defects in material and workmanship for a period of 5 years from the date of start up in accordance with manufacturer's standard published limited warranty.
- B. The warranty shall be comprehensive. Warranty coverage shall include parts, labor. Travel expenses, and labor to remove/re-install equipment.
- C. A warranty by a generator set manufacturer which places responsibility on the engine or generator manufacturer shall not be acceptable.

5.03 Service and Support

- A. Submit an agreement for continued service and maintenance of the emergency system, for the Owner's possible acceptance. Offer price, terms and conditions for furnishing parts and providing continued testing and servicing, including replacement of materials and equipment, for a one year period following the expiration of the warranty period, with option for renewal of agreement by Owner.
- B. The manufacturer of the generator set shall maintain service parts inventory at a central location which is accessible to the service location 24 hours per day, 365 days per year.
- C. The generator set shall be serviced by a local service organization that is trained and factory certified in generator set service. The supplier shall maintain an inventory of critical replacement parts at the local service organization, and in service vehicles. The service organization shall be on call 24 hours per day, 365 days per year.
- D. The manufacturer shall maintain model and serial number records of each generator set provided for at least 20 years.

5.04 Diagnostic Software ²

- A. Four copies of any or all necessary software required to diagnose and clear alarms and fault codes, read historical and performance data, etc. for both the generator controllers and the ATS, shall be provided to TAMU's Utilities and Energy Services EPSS team prior to commissioning and will be verified as



running properly on UES laptop during commissioning. Upgrades required to maintain the software's functionality shall be provided free of charge for the life of the asset or up to 30 years.

PART 6 - REVISIONS TO DESIGN STANDARD

Revision #	Date	Location	Brief Description
1	12/20/2017	2.01A	Stewart & Stephenson added to list of acceptable product manufacturers
2	12/20/2017	Part 5	Section 5.04 added to standard

Design Standard

Automatic Transfer Switches

Detailed specifications follow.

PART 1 - GENERAL

1.01 System

- A. Furnish the automatic transfer switches to automatically transfer between the normal and emergency power source

1.02 Applicable Standards

- A. The automatic transfer switches covered by these specifications shall be designed, tested, and assembled in strict accordance with NEC 70E and all applicable standards of ANSI, U.L., IEEE and NEMA.

1.03 Submittals

- A. Manufacturer shall submit shop drawings for review, which shall include the following, as a minimum:
 - 1. Descriptive literature
 - 2. Plan, elevation, side, and front view arrangement drawings, including overall dimension, weights and clearances, as well as mounting or anchoring requirements and conduit entrance locations.
 - 3. Schematic diagrams.
 - 4. Wiring diagrams.
 - 5. Accessory list.

PART 2 - PRODUCTS

2.01 Acceptable Manufacturers

- A. ASCO
- B. Russelectric
- C. Zenith

2.02 Construction

- A. General
 - 1. The automatic transfer switch shall be furnished as shown on the drawings. Voltage and continuous current ratings and number of poles shall be as shown.
 - 2. On 3 phase, 4 wire systems, utilizing ground fault protection, a true 4-pole switch shall be supplied with all four poles mounted on a common shaft.



The continuous current rating and the closing and withstand rating of the fourth pole shall be identical to the rating of the main poles.

3. The transfer switch shall be mounted in a NEMA 1 enclosure, unless otherwise indicated. Enclosures shall be fabricated from 12-gauge steel. The enclosure shall be sized to exceed minimum wire bending space required by UL 1008.
4. The transfer switch shall be equipped with an internal welded steel pocket, housing an operations and maintenance manual.
5. The transfer switch shall be top and bottom accessible.
6. The main contacts shall be capable of being replaced without removing the main power cables.
7. The main contacts shall be visible for inspection without any major disassembly of the transfer switch.
8. All bolted bus connections shall have Belleville compression type washers.
9. When a solid neutral is required, a fully rated bus bar with required AL-CU neutral lugs shall be provided.
10. Control components and wiring shall be front accessible. All control wires shall be multiconductor 18 gauge 600-volt SIS switchboard type point to point harness. All control wire terminations shall be identified with tubular sleeve-type markers.
11. The switch shall be equipped with 90 degrees C rated copper/aluminum solderless mechanical type lugs.
12. The complete transfer switch assembly shall be factory tested to ensure proper operation and compliance with the specification requirements. A copy of the factory test report shall be delivered with shipping unit.

B. Automatic Transfer Switch

1. The transfer switch shall be double throw, actuated by two electric operators momentarily energized, and connected to the transfer mechanism by a simple over center type linkage. Minimum transfer time shall be 400 milliseconds.
2. The normal and emergency contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing. Main contacts shall be mechanically locked in both the normal and emergency positions without the use of hooks, latches, magnets, or springs, and shall be silver-tungsten alloy. Separate arcing contacts with magnetic blowouts shall be provided on all transfer switches. Interlocked, molded case circuit breakers or contactors are not acceptable.
3. The transfer switch shall be equipped with a safe external manual operator, designed to prevent injury to operating personnel. The manual operator



shall provide the same contact to contact transfer speed as the electrical operator to prevent a flashover from switching the main contacts slowly. The external manual operator shall be safely operated from outside of the transfer switch enclosure while the enclosure door is closed.

C. Automatic Transfer Switch Controls

1. The transfer switch shall be equipped with a microprocessor based control system, to provide all the operational functions of the automatic transfer switch. The controller shall have two asynchronous serial ports. The controller shall have a real time clock with NiCad battery back-up.
2. The CPU shall be equipped with self diagnostics which perform periodic checks of the memory I/O and communication circuits, with a watchdog/power fail circuit.
3. The controller shall use industry standard open architecture communication protocol for high-speed serial communications via multidrop connection to other controllers and to a master terminal with up to 4000 ft of cable, or further, with the addition of a communication repeater. The serial communication port shall be RS422/485 compatible.
4. The serial communication port shall allow interface to either the manufacturer's or the owner's furnished remote supervisory control.
5. The controller shall have password protection required to limit access to qualified and authorized personnel.
6. The controller shall include a 20 character, LCD display, with a keypad, which allows access to the system.
7. The controller shall include three-phase over/under voltage, over/under frequency, phase sequence detection and phase differential monitoring on both normal and emergency sources.
8. The controller shall be capable of storing the following records in memory for access either locally or remotely:
 - a. Number of hours transfer switch is in the emergency position (total since record reset).
 - b. Number of hours emergency power is available (total since record reset).
 - c. Total transfer in either direction (total since record reset).
 - d. Date, time, and description of the last four source failures.
 - e. Date of the last exercise period.
 - f. Date of record reset.



D. Sequence of Operation

1. When the voltage on any phase of the normal source drops below 80% or increases to 120%, or frequency drops below 90%, or increase to 110%, or 20% voltage differential between phases occurs, after a programmable time delay period of 0-9999 seconds factory set at 3 seconds to allow for momentary dips, the engine starting contacts shall close to start the generating plant.
2. The transfer switch shall transfer to emergency when the generating plant has reached specified voltage and frequency on all phases.
3. After restoration of normal power on all phases to a preset value of at least 90% to 110% of rated voltage, and at least 95% to 105% of rated frequency, and voltage differential is below 20%, an adjustable time delay period of 0-9999 seconds (factory set at 300 seconds) shall delay retransfer to allow stabilization of normal power. If the emergency power source should fail during this time delay period, the switch shall automatically return to the normal source.
4. After retransfer to normal, the engine generator shall be allowed to operate at no load for a programmable period of 0-9999 seconds, factory set at 300 seconds.

E. Automatic Transfer Switch Accessories

1. Programmable three phase sensing of the normal source set to pickup at 90% and dropout at 80% of rated voltage and overvoltage to pickup at 120% and dropout out at 110% of rated voltage. Programmable frequency pickup at 95% and dropout at 90% and over frequency to pickup at 110% and dropout at 105% of rated frequency. Programmable voltage differential between phases, set at 20%, and phase sequence monitoring.
2. Programmable three phase sensing of the emergency source set to pickup at 90% and dropout at 80% of rated voltage and overvoltage to pickup at 120% and dropout out at 110% of rated voltage programmable frequency pickup at 95% and dropout at 90% and over frequency to pickup at 110% and dropout at 105% of rated frequency. Programmable voltage differential between phases set at 20%, and phase sequence monitoring.
3. Time delay for override of momentary normal source power outages (delays engine start signal and transfer switch operation). Programmable 0-9999 seconds. Factory set at 3 seconds, if not otherwise specified.
4. Time delay to control contact transition time on transfer to either source. Programmable 0-9999 seconds, factory set at 3 seconds.
5. Time delay on retransfer to normal, programmable 0-9999 seconds, factory set at 300 seconds if not otherwise specified, with overrun to provide programmable 0-9999 second time delay, factory set at 300 seconds, unloaded engine operation after retransfer to normal.



6. Time delay on transfer to emergency, programmable 0-9999 seconds, factory set at 3 seconds.
7. A maintained type load test switch shall be included to simulate a normal power failure, keypad initiated.
8. A remote type load test switch shall be included to simulate a normal power failure, remote switch initiated.
9. A time delay bypass on retransfer to normal shall be included. Keypad initiated.
10. Contact, rated 10 Amps 30 volts DC, to close on failure of normal source to initiate engine starting.
11. Contact, rated 10 Amps 30 volts DC, to open on failure of normal source for customer functions.
12. Light emitting diodes shall be mounted on the microprocessor panel to indicate: switch is in normal position, switch is in emergency position and controller is running.
13. A plant exerciser shall be provided with (10) 7-day events, programmable for any day of the week and (24) calendar events, programmable for any month/day, to automatically exercise generating plant programmable in one-minute increments. Also include selection of either "no load" (switch will not transfer) or "load" (switch will transfer) exercise period. Keypad initiated.
14. Provision to select either "no commit" or "commit" to transfer operation in the event of a normal power failure shall be included. In the "no commit position," the load will transfer to the emergency position unless normal power returns before the emergency source has reach 90% of it's rated values (switch will remain in normal). In the "commit position" the load will transfer to the emergency position after any normal power failure. Keypad initiated.
15. Two auxiliary contacts rated 10 Amp, 120 volts AC (for switches 100 to 800 amps) 15 amp, 120 volts AC (for switches 1000 to 4000 amps), shall be mounted on the main shaft, one closed on normal, the other closed on emergency. Both contacts will be wired to a terminal strip for ease of customer connections.
16. A three phase digital LCD voltage readout, with 1% accuracy shall display all three separate phase to phase voltages simultaneously, for both the normal and emergency source.
17. A digital LCD frequency readout with 1% accuracy shall display frequency for both normal and emergency source.
18. An LCD readout shall display normal source and emergency source availability.



F. Specifiers Notes:

The following accessories shall be available by simple activation, via the keypad, if required.

1. Include (2) time delay contacts that open simultaneously just (milliseconds) prior to transfer in either direction. These contacts close after a time delay upon transfer. Programmable 0-9999 seconds after transfer.
2. A block transfer function shall be included, energized from a 24VDC signal from the generator control switchgear, to allow transfer to emergency.
3. A load-shed function shall be included, energized from a 24VDC signal from the generator control switchgear, to disconnect the load from the emergency source when an overload condition occurs.
4. A peak shave function shall be included, energized from a 24VDC signal from the generator control switchgear. This function will start the emergency generator and transfer the ATS to the emergency source reducing the utility supply to the building. After the peak shave signal is removed, the transfer switch will retransfer to the normal supply, bypassing the retransfer time delay.

G. Approval

1. As a condition of approval, the manufacturer of the automatic transfer switches shall verify that their switches are listed by Underwriters Laboratories, Inc., Standard UL-1008 with 3 cycle short circuit closing and withstand as follows:

RMS Symmetrical Amperes 480 VAC

Current Limiting

<u>Amperes</u>	<u>Closing and Withstand</u>	<u>Fuse Rating</u>
100 – 400	42,000	200,000
600 – 800	65,000	200,000
1000 – 1200	85,000	200,000
1600 – 4000	100,000	200,000

2. During the 3 cycle closing and withstand tests, there shall be no contact welding or damage. The 3 cycle tests shall be performed without the use of current limiting fuses. The test shall verify that contacts separation has not occurred, and there is contact continuity across all phases. Test procedures shall be in accordance with UL-1008, and testing shall be certified by Underwriters' Laboratories, Inc.
3. When conducting temperature rise tests to UL-1008, the manufacture shall include post-endurance temperature rise tests to verify the ability of the



transfer switch to carry full rated current after completing the overload and endurance tests.

4. The microprocessor controller shall meet the following requirements:
 - a. Storage conditions - 25 degrees C to 85 degrees C.
 - b. Operation conditions - 20 degrees C to 70 degrees C ambient.
 - c. Humidity 0 to 99% relative humidity, noncondensing.
 - d. Capable of withstanding infinite power interruptions.
 - e. Surge withstand per ANSI/IEEE C-37.90A-1978.
5. Manufacturer shall provide copies of test reports upon request.

H. Manufacturer

1. The transfer switch manufacturer shall employ a nationwide factory-direct, field service organization, available on a 24-hour a day, 365 days a year, call basis.
2. The manufacture shall include an 800-telephone number, for field service contact, affixed to each enclosure.
3. The manufacturer shall maintain records of each transfer switch, by serial number, for a minimum 20 years.

PART 3 - EXECUTION

3.01 Installation

- A. Automatic Transfer Switches shall be provided with adequate lifting means for ease of installation of wall or floor mounted enclosures.
- B. Provide access and working space as indicated or as required.

3.02 Adjustments

- A. Tighten assembled bolted connections with appropriate tools to manufacturer's torque recommendations prior to first energization.