Section 17

Engine Driven Generator Sets

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17.1.01 General

A. This specification defines the requirements for an emergency or standby Electric Generator Set for wastewater pumping stations. The generator set shall consist of a diesel or natural gas-powered engine directly coupled to an electric generator, together with the necessary controls and accessories to provide electric power for the duration of any failure of the normal power supply.

   Any and all local or state requirements for standby power systems not covered by this specification will be the responsibility of the Contractor, supplier and manufacturer to meet.

B. Housing developments of 200 or more units shall provide backup generator sets for emergency use as required (Note #2 on Drawing L-8). Generator shall be provided with automatic throw over (transfer) switch that senses power interruption from the main power source, starts the generator and shifts the power supply to the lift station from the generator.

17.1.02 Design Standards

A. The equipment covered by these specifications shall be designed, tested, rated, assembled and installed in strict accordance with all applicable standards of ANSI, NEC, ISO, U.L., IEEE and NEMA.

B. The Contractor shall provide a complete integrated emergency generator system. The system consists of a diesel generator set with related component accessories and Automatic Transfer Switch(es) as specified herein.

C. The generator set shall have the following characteristics:

Voltage	240/480 (As Required By Power Supply)
Phase	3
Connection	Y
Wire	4
Hertz	60
Power Factor	0.8

   The generator set shall be capable of starting and running the existing loads and proposed loads without exceeding the maximum voltage and frequency variations specified herein, or the maximum temperature limitations of the engine and generator. The generator set shall be capable of starting all motor loads, with the non-inductive load applied first.

A. Terminals on all terminal blocks shall be individually identified.

17.1.03 Acceptable Manufacturers

A. Quality and Experience: All materials and parts of the generator set shall be new and unused. Each component shall be of current manufacture from a firm regularly engaged in the production of such equipment, as listed in the Approved Manufacturers' Products List, Section 18. Units and components offered under these specifications shall be covered by the manufacturers'' standard warranty on new machines, a copy of which shall be included in the submittal.

B. There shall be one source responsibility for warranty, parts and service through a local representative with factory trained service personnel.

17.1.04 Submittals

A. Engine-generator submittals shall include the following information:
   1. Factory published specification sheet indicating standard and optional accessories, ratings, etc.
   2. Manufacturers'' catalog cut sheets of all auxiliary components such as Automatic Transfer Switches, battery charger, control panel, enclosure, main circuit breaker, etc.
   3. Dimensional elevation and layout drawings of the generator set, enclosure and transfer switchgear and related accessories.
   4. Weights of all equipment.
   5. Concrete pad recommendation, layout and stub-up locations of electrical and fuel systems.
   6. Interconnect wiring diagram of complete emergency system, including generator, switchgear, day tank, remote pumps, battery charger, jacket water heater, remote alarm indications.
   7. The bidder shall submit with his submittal an estimate of engine mechanical data including heat rejection, exhaust gas flows, combustion air and ventilation air flows, noise data, fuel consumption, etc. when operating at 100% load. These estimates shall be based on manufacturers'' data.
   8. Generator electrical data including temperature and insulation data, cooling requirements, excitation ratings, voltage regulation, voltage regulator, efficiencies, waveform distortion and telephone influence factor.
   9. Generator resistances, reactances, and time constants.
   10. Generator motor starting capability.
   11. Control panel schematics.
   12. Oil sampling analysis, laboratory location, and information.
   13. Manufacturers'' and dealer's written warranty.

B. Operation and Maintenance Information. The system supplier shall furnish five sets of operating, maintenance and parts manuals to IRCDUS covering all components for the generator set system. The supplier shall also instruct the Owner and/or IRCDUS in operation and maintenance of the unit.

17.1.05 Warranty

A. The manufacturers'' standard warranty shall in no event be for a period of less than five (5) years from date of initial start-up of the system and shall include repair parts, labor, reasonable travel expense necessary for repairs at the job site, and expendables (lubricating oil, filters, antifreeze, and other service items made unusable by the defect) used during the course of repair. Submittals received without written warranties as specified will be rejected in their entirety.

17.1.06 Parts and Service Qualifications

A. Engine driven generator sets which can be properly maintained and serviced without causing IRCDUS either to carry expensive parts stock or to be subjected to the inconvenience of long periods of interrupted service because of lack of available parts. The supplier shall specify the nearest location of permanent parts outlets from which parts may be obtained.

B. The engine-generator supplier shall have service facilities within 75 miles of the project site and maintain 24-hour parts and service capability. The distributor shall stock parts as needed to support the generator set package for this specific project.

C. The dealer shall maintain qualified, factory trained service personnel that can respond to an emergency call within 2 hours of notification, 24 hours per day.

PART 2 – PRODUCTS

17.2.01 GENERAL REQUIREMENTS

A. The equipment supplied and installed shall meet the requirements of the NEC and all applicable local codes and regulations. All equipment shall be of new and current production by a MANUFACTURER who has 25 years of experience building this type of equipment. Units and components offered under these specifications shall be covered by the manufacturers'' standard warranty on new machines, a copy of which shall be included in the submittal. Manufacturer shall be ISO9001 certified.

B. The system shall be free of injurious torsional and bending vibrations within a speed range from 10% below to 10% above synchronous speed.

C. The system shall be adequately guarded both physically and electrically for protection of operating personnel.

17.2.02 ENGINE

A. General Description. The engine shall be of the internal combustion type equipped to operate on natural gas, at locations where natural gas is available or No. 2 diesel fuel.

B. Engine Power Rating. The rated net horsepower of the engine at the generator synchronous speed, with all accessories, shall not be less than that required to produce the KW required. The horsepower rating shall take into account generator efficiency and all parasitic losses such as fan, battery charger, etc. The generator set shall be capable of producing the required KW (without overload) for the duration of the power outage (standby rating), under the following ambient conditions:

Altitude, feet	1000
Ambient temperature range, ^{o}F	0-100
Humidity at max. ambient temp. %	80

C. Fuel and Oil Consumption. Accompanying the supplier's bid, the bidder shall supply fuel and oil consumption estimates based on engine manufacturers'' data, a copy of which shall be included in the submittal.

D. Governor (Engine Speed Control). The engine shall be equipped with a suitable governor to maintain frequency within limits, as specified below, by controlling engine and generator speed.

1. Type: isochronous
2. Stability: 1/4% maximum steady state frequency variation at any constant load from no load to full load.
3. Regulation: 1/4% maximum frequency deviation between no-load steady state and full-load steady state.
4. Transient: 5% maximum frequency dip on most severe motor starting condition.
5. Transient: 2 seconds maximum recovery time for maximum motor start.
6. The manual speed adjusting control shall be mechanical or electrical if located on the generator set or electrical if located in a remote control panel.

E. Engine Crank-Start System. The engine shall be electric start, provided with a solenoid energized motor, with either positive engagement or clutch drive to the engine.

1. Lead-calcium batteries shall be furnished to provide power to the engine cranking motor. The batteries shall be designed for operation at a minimum ambient temperature of 0 ºF.
2. The voltage shall be as required by the engine manufacturer.
3. The batteries shall be capable of a minimum of four crank cycles (rolling) of the specified prime mover and have sufficient current available for "break-away" currents for the particular engine used at the specified worse case temperature.
4. A float type battery charger, compatible with the batteries selected, shall be furnished which shall maintain the starting batteries at full charge. The charging system shall permit charging from either the normal or the emergency power source. It shall have a high rate and low rate charging system. A voltmeter shall indicate the charge rate and the circuit will be protected by either fuses or circuit breakers. The charger or charging circuit shall be so designed that it will not be damaged during the engine cranking, achieved, for example, by a current limiting charger or a crank disconnect relay. It shall also be capable of recharging a discharged battery in 12 hours while carrying normal loads.

F. Engine Cooling System. The engine shall be liquid cooled. The type of liquid cooling system shall be a unit mounted radiator. The radiator capacity shall be suitable for operation in the ambient temperature specified in paragraph 17.2.02, plus the air temperature rise across the engine.

G. Air Supply/Exhaust System.

1. Cleaner: An air cleaner and silencer shall be furnished as recommended by the engine manufacturer and shall be located and mounted as recommended by the engine manufacturer.
2. Exhaust: An exhaust system of suitable size, configuration and material in accordance with engine manufacturers'' recommendations shall connect the exhaust outlet of the engine to the silencer. The type of silencer shall meet the requirements of engine manufacturers and shall be residential silencing type.
   a. The exhaust system and silencer shall have the configuration shown on the drawings, and shall be of such size that back pressure on the system will not exceed the back pressure permitted by the manufacturers'' recommendation. A flexible connection shall be mounted at the engine exhaust outlet and the discharge end of the exhaust line shall be protected against entry of precipitation. Piping within reach of personnel shall be protected by screening or suitable lagging. All exhaust piping shall be gas tight.

H. Engine Protective Devices. The following engine protective devices shall be provided, and an indicator light shall be supplied for use with each device specified.

1. Alarm system for high water temperature and/or low oil pressure.
2. Automatic engine shutdown for high water temperature and/or low oil pressure.
3. Combination alarm and shutdown system for high water temperature and/or low oil pressure.
4. Engine overspeed automatic shutdown device.
5. Engine failed to start indicator light (overcrank).
6. Alarm for low coolant level.
7. A shunt trip and undervoltage trip shall be incorporated to cause the circuit breaker to open simultaneously with any automatic shutdown of the engine.

I. Fuel Supply for Engine.

1. Main Fuel Storage Tank:

   A fuel storage tank shall be manufactured of corrosion resistant material and sized to allow full capacity generator operation for a minimum of seventy-two hours without refilling with a maximum fuel capacity of 500 gallons. A fuel storage tank shall be located in the place indicated on the plans and shall be complete with all piping and fittings connected. The tank shall be new and unused, and no galvanized material shall be used in the tank or system. The tank shall be furnished with faucet valve located in the supply pipe of the tank and a check valve incorporated to ensure prime is maintained. The tank shall be vented to atmosphere. Location and installation of the fuel storage shall be in accordance with applicable government, insurance restrictions, and local building code. A fuel level gauge shall be located at the tank.)

2. Main Fuel Delivery System: A system shall be supplied to deliver an adequate amount of fuel to the engine from the storage tank. Pipe sizes shall be no smaller than the minimum recommended by the engine manufacturer to avoid fuel flow restriction. The engine supply and return line shall be equipped with a length of flexible fuel lines, unions and gate valves. No copper lines are acceptable.

3. The system shall include an engine driven transfer pump of sufficient lift and capacity to deliver fuel at the maximum required rate from the storage tank to the engine. A check valve shall be furnished in supply line at engine.

17.2.03 GENERATOR

A. Description. The generator shall meet all requirements of NEMA MG-1, Part 22, in design, performance and factory test procedures. The regulator shall be factory wired and tested with the generator. The generator shall have the characteristics and ratings required by paragraph 22.10.

B. Excitation System. The generator shall be equipped with a permanent magnet generator (PMG) excitation system. Both the PMG and the rotating brushless exciter shall be mounted outboard of the bearing. The system shall supply a minimum short circuit support current of 300% of the standby rating for 10 seconds. The rotating exciter shall use a three phase full wave rectifier assembly with hermetically sealed silicon diodes protected against abnormal transient conditions by a multi-plate selenium surge protector.

C. Construction. The insulation system of both the rotor and stator shall be of NEMA Class H materials and shall be synthetic and non-hygroscopic. Field windings shall be on the rotor, and the rotor core shall be shrunk-fit and keyed to the shaft. The stator winding shall be of 2/3 pitch design to eliminate the third harmonic. Units rated above 1500 kW or 601 volts or higher shall be form wound.

    1. The temperature rise of both the rotor and the stator shall be in accordance with the applicable sections of NEMA MG-1-22, BS-5000 part 99, or CSA C22.2, for the type of service intended. The generator shall be self-ventilated.

D. Conduit Box. Load connections shall be made in the front-end mounted junction box. The generator construction will allow connection to the load through the top, bottom or either side of the junction box.

    1. The conduit box shall contain two compartments: one to house the rotating rectifier and PMG, and the other to house the connection area and regulator. This is to separate the rotating elements from the load connection and voltage regulator adjustments.

E. Verification of Performance. All performance and temperature rise data submitted by the bidder shall be the result of the actual test of the same or duplicate generators. Temperature rise data shall be the result of full load, 0.8 power factor heat runs at the rated voltage and hertz. All performance testing shall be done in accordance with MIL-STD-705 and/or IEEE Standard-115.

F. Efficiency. The generator efficiency shall be determined in accordance with NEMA MG-1, paragraph 22.44. All test results shall be submitted to the Engineer for approval.

17.2.04 VOLTAGE REGULATION

A. The generator shall be equipped with a voltage regulator to maintain voltage within limits as specified below:

   1. Stability: 1/2% maximum voltage variation at any constant load from no load to full load.
   2. Regulation: 1% maximum voltage between no load steady state and full load steady state.
   3. Transient: 20% maximum voltage dip in most severe motor starting condition. See paragraph 1.01.
   4. Transient: Two (2) seconds maximum voltage recovery time with application or removal of 0.8 power factor full load.

B. The regulator shall be a solid state type using transistors or SCR's. The unit shall include volts/hertz underspeed protection, three-phase RMS sensing, and overexcitation protection. The regulator shall also provide loss of sensing protection, regulator current limit, temperature protection and an engine unloading circuit. EMI suppression shall be provided meeting MIL-STD-461B, part 9 standards.

17.2.05 GENERATOR FULL MAIN LINE CIRCUIT BREAKER

A. A generator main circuit breaker shall be provided rated at manufacturers recommended amperes minimum frame size, and volts, 100% rated. The interrupting capability shall be greater than the generator short circuit capability, but not less than 60,000/30,000 symmetrical amperes at 240/480 volts. The breaker continuous current trip rating shall be selected to provide overload protection for the generator.

B. The breaker shall be provided with a shunt trip device. The generator starting circuit battery system will be used as the power source for the shunt trip circuit. The shunt trip coil voltage shall be suitable for use on the starting circuit.

C. The breaker shall include three (3) normally open and three (3) normally closed auxiliary contacts.

D. The breaker shall be a NEMA 4X.

17.2.06 AUTOMATIC START AND STOP CONTROLS

A. General Description. Automatic starting and stopping controls shall be furnished to start the engine automatically when the normal electric power fails or falls below specific limits and to stop the engine automatically after the normal power supply resumes. The signal for starting or stopping the engine shall be from an external auxiliary

contact. The controls shall be capable of operating at 50% of normal DC system supplied voltage.

B. Engine Cranking Control. Crank control and time delay relays shall provide at least one cranking period. If only one cranking period is provided, its duration shall be at least 15 seconds. If more than one cranking attempt is provided, each cranking period shall be for at least seven (7) seconds, and the cranking attempts shall be separated by appropriate rest periods. A sensing device shall automatically disconnect the starting circuit when the engine has started. If the engine has not started at completion of the starting program, the overcranking signal shall so indicate. The engine starting controls shall be locked out and no further starting attempts shall take place until the overcranking device has been manually reset.

C. Selector Switch. A selector switch shall be incorporated in the automatic engine start and stop controls. It shall include an "off" position that prevents manual or automatic starting of the engine, a "manual" or "handcrank" position that permits the engine to be started manually by the pushbutton on the control cabinet and run unloaded; an "automatic" position which readies the system for automatic start or stop on demand of the automatic load transfer switch or a programmed exerciser.

D. Manual Test Operation. It shall be possible to start the engine manually and run it unloaded by a manual pushbutton on the control cabinet that causes the engine to start, run and stop through the automatic start and stop controls.

17.2.07 INSTRUMENTATION

B. Instruments and Controls. The following engine and generator instruments and controls shall be furnished and installed:

1. A.C. ammeter
2. A.C. voltmeter
3. Governor speed adjusting control
4. Water temperature gauge
5. Oil Pressure gauge
6. Manual start/stop control
7. Voltmeter/ammeter phase selector switch
8. Elapsed time meter
9. Panel lights
10. Indicator lights for engine alarm

All wiring and interconnections shall be in accordance with commercial electrical standards.

C. Location

1. All of the foregoing instruments, lights and controls shall be mounted in a control panel on the generator set. All instrumentation must be isolated from engine generator set vibration.
2. In addition, an ammeter, voltmeter, and “generator ready" light, a start/stop control, and an audible alarm and alarm light shall be provided in a generator control panel to be remotely wall mounted. The audible alarm and alarm light shall operate for any of the engine or generator alarms provided on the local control panel. Cable between the local and remote-control panels shall be provided.

D. Panel Design. All instruments, controls and indicating lights shall be properly identified. All wires shall be individually identified and must agree with wiring diagrams provided.

17.2.08 ACCESSORIES

A. Enclosure. The entire engine-generator assembly, including the battery, battery charger, day tank, lift pump, control panel, and radiator shall be enclosed in an aluminum sound attenuated enclosure suitable for an outdoor environment. The enclosure shall attenuate to a decibel level of 65-70 dB at a distance of 7 meters horizontally in any direction around the entire generator enclosure. The enclosure shall meet all local, state and federal wind load standards. Provisions shall be made on the enclosure for mounting the engine exhaust silencer. Louvers or dampers shall be provided to allow adequate radiator ventilation during operation without reducing the rating of the engine-generator unit. Doors shall be provided as required for access to the engine and control panel. Generator pad / platform shall have a maintenance walk a minimum of 3’-0” wide around three sides of the generator, also see plans. Stairs shall be provided from grade to the pad / platform where the elevation difference is greater than 1’ – 0” from final grade to the top of the generator pad / platform.

B. Block Heater. An engine block heater shall be provided to keep the engine coolant at a temperature of 85° F with the ambient temperature at the minimum specified in paragraph 2.02. The heater shall be suitable for operation at 120/240 **(NOTE TO DESIGNER Select desired voltage)** volts AC, single phase.

C. Control Panel Heater. A heater shall be provided in the control panel to keep the interior of the panel above 40° F when at the minimum ambient temperature specified in paragraph 17.2.02. The heater shall be operated by a thermostat, and shall be suitable for operation at 120 volts ac, single phase.

17.2.09 TRANSFER SWITCH

A. Automatic Transfer (Throw Over) Switches required with a stainless steel 4X breaker disconnect cabinet, as approved by IRCDUS Engineer.

17.2.10 TELEMETRY

A. Telemetry equipment required as approved by IRCDUS Engineer.

PART 3 – EXECUTION

17.3.01 INSTALLATION

A. Install equipment in accordance with manufacturers'' recommendations, the project drawings and specifications, and all applicable codes. Installation of the system includes but is not limited to pouring a concrete pad for the generator set and automatic transfer switch, receiving and offloading the equipment, providing all labor, permits and material to install the total system.

B. Mounting. The mounting of the generator set shall be sufficiently rigid to maintain alignment and to minimize the engine and generator stresses. The floor loading shall not exceed 5000 lbs. per sq. ft. A suitable number of spring type, vibration, rubber type, and fiberglass isolators shall be inserted between the engine generator set and the floor.

C. Placement on Site. Refer to Drawing L-4 and L-5 for typical placement of emergency generators on wastewater pumping station sites in Plan Views “A” and “B”.

17.3.02 START-UP AND TESTING

A. Acceptance Test. A complete system load test shall be performed after all equipment is installed. The extent of testing shall be at the discretion of the engineer. The completed generator set shall be tested at 1.0 power factor for a period of one hour at full load prior to shipment to the job site. In addition, the generator set supplier shall include in his bid the cost of an on site, full load test (using portable resistive type load banks or building load or combination thereof) for a minimum of four hours in the presence of a representative of the Owner and/or Engineer before final acceptance.

B. Coordinate all start-up and testing activities with the Engineer, Owner, and IRCDUS.

C. After installation is complete and normal power is available, the manufacturers'' local dealer shall perform the following:

1. Verify that the equipment is installed properly.
2. Check all auxiliary devices for proper operation, including battery charger, jacket water heater(s), generator space heater, remote annunciator, etc.
3. Test all alarms and safety shutdown devices for proper operation and annunciation.
4. Check all fluid levels.
5. Start engine and check for exhaust, oil, fuel leaks, vibrations, etc.
6. Verify proper voltage and phase rotation at the transfer switch before connecting to the load.
7. Connect the generator to building load and verify that the generator will start and run all designated loads in the plant.

D. Perform a 4 hour load bank test at full nameplate load using a load bank and cables supplied by the local generator dealer. Observe and record the following data at 15 minute intervals:

1. Service meter hours
2. Volts AC - All phases
3. Amps AC - All phases
4. Frequency
5. Power factor or Vars
6. Jacket water temperature
7. Oil Pressure
8. Fuel pressure
9. Ambient temperature

E. Operation and Maintenance Manuals

1. Provide TWO (2) sets of operation and maintenance and manuals covering the generator, switchgear, and auxiliary components. Include parts manuals, final as-built wiring interconnect diagrams, start-up test reports, and recommended preventative maintenance schedules.
2. Ventilation Requirements. The bidder shall submit with his submittal an estimate of air flow requirements for cooling and combustion, plus an estimate of heat rejection of the engine and generator when operating at 100% load. These estimates shall be based on manufacturers'' data.

F. Training

1. Provide one day of on-site training to instruct the Owner's personnel in the proper operation and maintenance of the equipment. Review operation and maintenance manuals, parts manuals, and emergency service procedures.

G. The CONTRACTOR shall provide a full tank of diesel fuel for the

completion of all testing.

END OF SECTION