ENGINE DRIVEN GENERATOR SETS

GUIDELINE SPECIFICATIONS
FOR
EMERGENCY OR STANDBY

EGSA 101S, 1995a

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SCOPE

This guideline specification is for use in preparing specifications for emergency or standby engine driven electric generating systems.

It is a flexible, "fill in the blank" type guideline to be used for sets generally of the stationary type from 25 to 2,000 kW. Your local EGSA member will be more than willing to assist in tailoring this specification to suit a specific installation or particular application. The specification writer should verify which local and/or national codes apply and modify the specification as may be required.

You will find instructions are always printed in capitals (LIKE THIS). Whenever you see a line (_____), this means you must specify the desired performance level. A box [] will be provided where equipment must be checked if desired.

We have taken special care to keep these sample specifications non-restrictive. So, if you plan to use the specifications for competitive bidding, you can be sure that all qualified sources will have an equal opportunity to submit bids. Even if you are going to draw up your own set of specifications, the following information can still serve as a valuable check list to make sure you cover all important areas.

REFERENCE STANDARDS AND PRACTICES:

EGSA 100B-1992	Performance Standard for Engine Cranking Batteries for Use with Engine Generator Sets
EGSA 100C-1992	Performance Standard for Battery Chargers for Engine Starting and Control Batteries
EGSA 100E-1992	Performance Standard for Governors on Engine Generator Sets
EGSA 100G-1992	Performance Standard for Generator Set Instrumentation Control and Auxiliary Equipment
EGSA 100M-1992	Performance Standard for Multiple Engine Generator Set Control Systems
EGSA 100R-1992	Performance Standard for Voltage Regulators Used on Electric Generators
EGSA 100S-1992	Performance Standard for Transfer Switches for Use with Engine Generator Sets
EGSA 101G-1995	Glossary of Standard Industry Terminology and Definitions
EGSA 101P-1995	Engine Driven Generator Sets Performance Standard
EGSA 109C-1994	Codes for Emergency Power by States and Major Cities
NFPA 37 1993	National Electric Code, Articles 517, 700, 701, and 705
NFPA 99 1993	Essential Electrical System for Health Care Facilities
NFPA 110 1993	Standard for Emergency Power Supply Systems
IEEE 446-1987	IEEE Recommended Practice for Emergency and Standby Power Systems
NEMA MG-1 1994	National Electrical Manufacturers Assn. Standard for Motors and Generators
CSA C282-1989	Emergency Electrical Power Supply for Buildings
CSA Z32.4-1989	Essential Electrical Systems for Hospitals

SPECIFICATION

1. General Provisions and Requirements

1.1 **General Description --** This specification defines the requirements for an emergency or standby Electric Generator Set to be installed in ____

____

(structure and location) in accordance with architect's plans for that structure. The generator set shall consist of an engine directly coupled to an electric generator, together with the necessary switchgear, controls and accessories, to provide electric power for the duration of any failure of the normal power supply. The generator set shall have the following characteristics:

__________ kW capacity	__________ Power Factor
__________ kVA capacity	__________ Phase
__________ Volts	__________ Wire
__________ Hertz	

Maximum one step load at 0.8 P.F. is __________ kW.

The load to be served by this generator set consists of__________ kW non-inductive load plus __________ total motor horsepower. The motors shall be started as shown in the following table:

Table #1

Sequence	H.P.	Code Letter	Starting Method

NOTE: INDICATE THOSE MOTORS WHICH WILL START SIMULTANEOUSLY

The installation shall be made in accordance with the recommendations of the manufacturers and with the regulations of the national and local regulatory agencies.

NOTE: INDICATE IF MORE THAN ONE GENERATOR SET IS TO BE SUPPLIED. IF SO, OR IF ANOTHER GENERATOR IS ALREADY IN THE BUILDING, INDICATE WHETHER THEY ARE TO BE OPERATED INDEPENDENTLY OR IN PARALLEL. IF PARALLEL, SEE EGSA 100M .

1.2 **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. Units and components offered under these specifications shall be covered by the manufacturer's standard warranty on new machines, a copy of which shall be included in the submittal.

1.3 **Warranty --** The warranty specified in paragraph 1.2 shall be _______ year(s) or ______ hours from date of acceptance, whichever occurs first.

1.4 **Parts and Service --** Bids shall be accepted only on engine driven generator sets which can be properly maintained and serviced without causing the purchaser 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 bidder shall specify the nearest location of permanent parts outlets from which parts may be obtained.

1.5 **Operation and Maintenance Information --** The system supplier shall furnish one set of operating, maintenance and parts manuals covering all components for the generator set system. The supplier shall also instruct the owner in operation and maintenance of the unit.

1.6 **Torsional Vibrations --** The system shall be free of injurious torsional and bending vibrations within a speed range from 10% below to 10% above synchronous speed.

1.7 **Guards --** The system shall be adequately guarded both physically and electrically for protection of operating personnel.

2. Engine

2.1 **General Description --** Engine shall be of the

[] Internal Combustion - Gasoline

[] Internal Combustion - Diesel

[] Internal Combustion - LPG, Natural Gas or Dual Fuel and will be equipped to operate on:

[] Gasoline fuel with an octane rating of ______

[] Diesel Fuel, grade ______

[] Natural gas with a BTU rating of ______

[] Liquid propane with a BTU rating of ______

2.2 **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 specified in Par. 1.1. 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 specified kW (without overload) for the duration of the power outage, under the following ambient conditions:

Altitude: ______ ft. ______ m.

Air temperature at engine intake ______ F.______ C.

Humidity Range: _______-_______%

NOTE: FOR INFORMATION ON FUEL STABILITY, SEE PAGE 28.

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

2.4 **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. (see EGSA Std.100E)

Type: __________ isochronous, or __________ droop
(__________% droop)

Stability: _______% maximum steady state frequency variation at any constant load from no load to full load.

Regulation: _______% maximum frequency deviation between no-load steady state and full-load steady state.

Transient: _______% maximum frequency dip on one-step application of 0.8 P.F. full load (see paragraph 1.1).

Transient: _______% maximum frequency overshoot on one-step removal of 0.8 P.F. full load.

Transient: _______% maximum frequency dip on most severe motor starting condition. See Table #1.

Transient: _______ seconds maximum recovery time for maximum motor start.

Transient: _______ seconds maximum recovery time for one-step load acceptance.

NOTE: FOR AID IN SPECIFYING GOVERNOR PERFORMANCE, SEE PAGES 28-29.

Manual speed adjusting control shall be mechanical or electrical if located on the generator set or electrical if located in a remote control panel (See Para. 7).

NOTE: IF TWO OR MORE GENERATOR SETS ARE TO BE OPERATED IN PARALLEL, ADD THE FOLLOWING SENTENCE AND SPECIFY ONLY ELECTRIC OR HYDRAULIC GOVERNORS.

[] Automatic load sharing shall be provided between generator sets operated in parallel.

2.5 **Engine Crank-Start System --**

NOTE: MOST STANDBY GENERATOR SETS HAVE A BATTERY-POWERED ELECTRIC STARTING SYSTEM, BUT UNDER SOME CONDITIONS AIR STARTING IS PREFERRED (REFER TO PAGE 30).

The engine(s) shall be electric start, provided with a solenoid energized motor, with either positive engagement or clutch drive to the engine.

The starting batteries shall be furnished for each set designed for an ambient temperature range at the engine from ______º F. ______ ºC. (max.) in accordance with engine manufacturers recommendations.

The voltage shall be as required by the engine manufacturer.

The battery 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.

The batteries shall be of the [] nickel cadmium, or [] lead acid type.

NOTE: THE TYPE OF BATTERY SHOULD BE CHOSEN FOR RELIABILITY AND LIFE DEPENDING ON THE APPLICATION, WITH COST COMMENSURATE WITH LIFE. REFER TO EGSA STD. 100B FOR MORE INFORMATION ON BATTERIES.

A float type battery charger, compatible with battery(s) 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. An [] ammeter [] 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.

NOTE: REFER EGSA PERFORMANCE STANDARD 100C 1980 FOR MORE INFORMATION ON BATTERY CHARGERS.

[] An air starter system shall be furnished on the engine and shall include an air starting motor, an air tank, automatic lubricator, DC starter solenoid valve, check valve, relay valve, silencer, tank drain valve, condensate trap and manually operated bypass valve.

NOTE: CONTROL BATTERY(S) SHALL BE REQUIRED.

2.6 **Engine Cooling System --** The engine shall be air cooled or liquid cooled. The type of liquid cooling system shall be: (direct city water cooling without heat exchanger not recommended by EGSA.)

[] Radiator (unit mounted) **-** consideration shall be given for air temperature rise across the engine and generator in addition to ambient.

[] Radiator (remote horizontal or remote vertical) motor, if used, shall be fed directly from the generator.

[] Heat Exchanger

[] Heat exchanger with cooling tower or remote radiator.

Minimum capacity shall be rated for 38ºC (100ºF) minimum engine ambient temperature plus air temperature rise across the engine.

NOTE: IN THE FOREGOING PARAGRAPH, SELECT ONE TYPE OF COOLING SYSTEM. A REMOTE RADIATOR CAN BE USED EFFECTIVELY TO REDUCE AIR FLOW REQUIREMENTS IN THE GENERATOR ROOM AND THUS ALSO REDUCE AMBIENT NOISE AT THE GENERATOR. IF REMOTE UNIT IS USED WHERE PREVAILING WIND IS A FACTOR, A HORIZONTAL UNIT IS RECOMMENDED.

2.7 **Air Supply/Exhaust System**

2.7.1 **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.

2.7.2 **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 a silencer. The type of silencer shall meet the requirements of engine manufacturers and shall be:

[] industrial silencing

[] residential silencing

[] critical silencing

The silencer shall be located

[] in the engine room

[] on the roof

[] on the side of the building

NOTE: IN THE FOREGOING PARAGRAPHS, SPECIFY TYPE AND LOCATION OF EXHAUST SILENCER.

The exhaust system including silencer shall be of such size that back pressure on the system will not exceed the back pressure permitted by the engine manufacturer's 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.

2.8 **Engine Protective Devices --** The following engine protective devices shall be provided, and an indicating light shall be supplied for use with each device specified.

NOTE: ARCHITECT/ENGINEER MAY SELECT FROM THE FOLLOWING LIST THOSE ITEMS DESIRED FOR A PARTICULAR INSTALLATION

[] Alarm system for high water temperature and/or low oil pressure.

[] Automatic engine shutdown for high water temperature and/or low oil pressure.*

[] Combination alarm and shutdown system for high water temperature and/or low oil pressure.

[] Engine overspeed automatic shutdown device.*

[] Engine failed to start indicator light (overcrank).*

[] Alarm for low coolant level.

*Minimum recommended

NOTE: IF GENERATOR SETS ARE TO BE OPERATED IN PARALLEL, ADD THE FOLLOWING SENTENCE:

[] A shunt trip or undervoltage trip shall be incorporated to cause the circuit breaker to open simultaneously with any automatic shutdown of the engine.

2.9 **Fuel Supply for Engine**

2.9.1 **Main Fuel Storage Tank**: A fuel storage tank with sufficient fuel capacity to allow the unit to operate continuously for ______ hours 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 ____

NOTE: THIS PARAGRAPH WILL NOT APPLY WHEN NATURAL GAS OR LPG IS USED AS A FUEL.

2.9.2 **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.

NOTE: IF THE STORAGE TANK IS LOCATED WITHIN 20 FEET OF THE ENGINE BUT MORE THAN 4 FEET BELOW IT, ADD PAR. "A" BELOW. IF THE STORAGE TANK IS LOCATED MORE THAN 20 FEET FROM THE ENGINE, USE PAR. "B" INSTEAD

[] (A) The system shall include an engine driven fuel supply 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.

[] (B) A ____ gallon day tank shall be located in the engine room. The day tank shall be provided with a check valve in the supply line to the engine. The tank shall be new and unused and shall not be galvanized. An AC electric pump shall be furnished to transfer fuel from the main storage tank to the day tank. The pump shall be supplied from the emergency bus. Lift and capacity of the pump shall be adequate to deliver fuel to the day tank at a rate in excess of the maximum fuel rate of the engine. The tank shall also be equipped with a manual hand priming pump. The tank shall be sized to a minimum requirement as determined by local fuel storage regulations and in accordance with requirements outlined by the engine manufacturer.

3. Generator

3.1 **Generator Description --** The generator shall be an engine-driven single or two bearing type, synchronous, brushless, conforming to applicable standards. It shall be connected to the engine flywheel by means of flexible type coupling for single bearing generators and elastic coupling for two bearing generators.

3.2 **Generator Rating --** The generator shall be rated at _____kW at 0.8 P.F. for ____ F. ____ C. ambient. Class of insulation shall be Class F or H and applicable to NEMA Standards. The voltage regulation shall be plus/minus 2% from no load to full load with plus/minus 5% speed change and a 15 C. rise in ambient room temperature as measured by the light beam oscillograph or equivalent. The generator voltage dip from no load to full load shall not exceed 22% as measured by the light beam oscillograph or equivalent. In the event that motor starting is specified in Table #1, page 3, and the motors shall be started

[] direct across the line, or

[] by reduced voltage starting, the generator/regulator combination shall be capable of starting the more severe load sequence with less than 30% voltage dip as measured by the light beam oscillograph or equivalent.

3.3 The supplier shall provide in the submittal the time and machine constants of the generator furnished.

4. Voltage Regulation

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

Stability: _______% maximum voltage variation at any constant load from no load to full load.

Regulation: _______% maximum voltage deviation between no load steady state and full load steady state.

Transient: _______% maximum voltage dip or overshoot on one-step application or removal of 0.8 P.F. full load.

Transient: _______% maximum voltage dip in most severe motor starting condition. See Table #1.

Transient: _______ seconds maximum voltage recovery time with application or removal of 0.8 P.F. full load.

FOR AID IN SPECIFYING VOLTAGE REGULATOR PERFORMANCE, SEE EGSA STD100R.

NOTE: IF GENERATOR SETS ARE TO BE OPERATED IN PARALLEL, ADD THE FOLLOWING SENTENCE:

[] The generator voltage regulator shall be equipped with reactive droop compensation or reactive differential compensation.

5. Generator Full Main Line Circuit Breaker

A main line circuit breaker may be supplied to disconnect the generator from its load.
It shall be _______ amps minimum.

6. Automatic Start and Stop Controls

6.1 **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 sensed through an auxiliary contact in the automatic transfer switch (described in para. 8). The controls shall be capable of operating at 50% of normal DC system supplied voltage.

NOTE: IF THE ENGINE HAS A BATTERY-POWERED ELECTRIC STARTING SYSTEM, USE PARA. 6.2 AND 6.3 BELOW. FOR AIR STARTING, USE PARA. 6.4 AND 6.5.

[] 6.2 **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 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 as 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.

NOTE: IT IS RECOMMENDED THAT A MINIMUM OF 3 CRANK ATTEMPTS BE INCORPORATED IN THE AUTO START DEVICE WHERE MULTIPLE CRANK ATTEMPTS ARE SPECIFIED.

[] 6.3 **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" or "test" position that permits the engine to be started 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.

[] 6.4 **Engine Cranking Control --** When normal electric power fails, a control valve shall be actuated automatically to start the air crank. A sensing device shall automatically shut off air power when the engine has started.

[] 6.5 **Manual Test Operation --** It shall be possible to start the engine manually and run it unloaded by a manual device that causes the engine to start, run and stop.

7. Instrumentation

7.1 **Instruments and Controls --** The following engine and generator instruments and controls shall be furnished and installed:

[] A.C. ammeter *

[] A.C. voltmeter *

[] Voltage adjusting rheostat *

[] Frequency Meter * ([] Vibrating Reed [] Dial Type [] Digital Electronic)

[] Governor speed adjusting control ([] Vernier [] Remote)

[] Water temperature gauge *

[] Oil Pressure gauge *

[] Manual start/stop control *

[] Voltmeter/ammeter phase selector switch *

[] Power factor meter or var meter

[] Wattmeter (essential for paralleling)

[] Elapsed time meter *

[] Panel lights *

[] Indicator lights for engine alarm *

[] Paralleling lights and switch (essential for paralleling)

[] Synchroscope and switch (optional for paralleling)

[] Reverse power relay (essential for paralleling)

[] Digital readouts for voltage, amperage, frequency

*basic recommended

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

7.2 **Location**

NOTE: ALL INSTRUMENTS MAY BE LOCATED IN A CONTROL PANEL MOUNTED ON A GENERATOR SET, OR SOME ENGINE INSTRUMENTS MAY BE LOCATED AT THE GENERATOR SET WHILE THE REMAINING INSTRUMENTS ARE MOUNTED IN A REMOTE GENERATOR CONTROL PANEL EITHER IN THE SAME ROOM OR IN A SEPARATE ROOM. THE REMOTE PANEL MAY BE WALL MOUNTED OR FREE STANDING. IF ALL INSTRUMENTS ARE ON A GENERATOR SET, USE PARA. 7.2.1 BELOW; OTHERWISE, USE PARA. 7.2.2 FOR MORE INFORMATION, REFER EGSA STD. 100G.

7.2.1 [] All of the foregoing instruments, lights and controls shall be mounted in a control panel on the generator set. The governor manual speed adjusting control may be either mechanical or electrical. All instrumentation must be isolated from engine generator set vibration.

7.2.2 [] The water temperature gauge, oil pressure gauge and manual start/stop control may be mounted on a gauge board on the generator set. All other instruments and controls shall be mounted in a generator control panel located_____________________________
____.

7.3 **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. Terminals on all terminal blocks shall be individually identified.

8. Transfer Switch

8.1 **Ratings --** The transfer switch shall have an electrical rating on the normal power source side of _______ volts, _______amps, _______ frequency, _______ poles, and on the alternator power source side of _______ volts, _______ amps, _______ phase, _______ frequency, and _______ poles.

8.2 **Load Classification -** The transfer switch shall be rated and marked for its total designated load.

NOTE: A TRANSFER SWITCH RATED FOR "TOTAL DESIGNATED LOAD" IS SUITABLE FOR TUNGSTEN, BALLAST, MOTORS AND RESISTANCE LOADS, EXCEPT TUNGSTEN LOADS CANNOT EXCEED 30% OF THE SWITCH RATING UNLESS MARKED OTHERWISE. SEE EGSA STD 100S, "AUTOMATIC TRANSFER SWITCH".

8.3 **Type -** Select type of transfer switch depending upon code and job requirements.

8.3.1 [] **Automatic --** An automatic transfer switch shall be provided. When the voltage of any phase drops _____% below normal power failure relays shall actuate contacts that cause the automatic engine starting control to start the engine. The switch shall transfer the load to the standby generator after the generator reaches nominal voltage and frequency. The load shall be restored to the normal power source when all phase voltages return to _____ % or more of nominal. The transfer switch and its control panel shall be listed to Underwriters Laboratory STD UL-1008. Automatic transfer switch shall be rated for a minimum withstanding and closing of _______ amp RMS.

8.3.2 [] **Manual --** A manual transfer switch shall be provided to transfer the load from the normal power source to the alternate source of supply with a positive means of assuring that the electrical power from the standby generator cannot be fed back into the normal power source lines or vice versa.

8.3.3 [] **Non-automatic**. A non-automatic transfer switch will have similar characteristics to the automatic transfer switch of the same rating, but less the automatic control logic, for manual remote control, and will be listed to Std. UL1008. See EGSA 100S article 3-2.

8.4 **Accessories for Transfer Switches**

8.4.1 For automatic type transfer switches, the following minimum standard accessories shall be installed in conjunction with the automatic transfer switch:

- Time Delay to override momentary power outages on the normal source

- Time Delay on retransfer to normal power (15 minutes minimum)

- Time Delay for engine cool down

- Signal contacts (engine starting)

- Test switch

- Voltage and frequency sensor - alternate source

- Manual operator

The following optional accessories shall be furnished when so indicated:

[] Fan contacts

[] Auxiliary contact to close on normal

[] Auxiliary contact to close on emergency

[] Indicator light normal power source

[] Indicator light alternate source

[] Exerciser time clock [] with load transfer

[] Time Delay on transfer to emergency (after engine generator has started)

[] Battery Charger voltage relays on normal source-adjustable

[] Bypass isolation switch for bypass to [] one source [] two sources

[] Transfer of highly inductive loads (e.g. motors, transformers).
Typical means are:
[] time delay in neutral position,
[] in phase monitor transfer, or
[] temporary control disconnect of inductive loads.

[] Switched neutral

8.4.2 For non-automatic transfer switch, the following mode of operation and accessories shall be installed in conjunction with the non-automatic transfer switch:

[] Operating means: [] Pushbutton [] Hand operated

[] Indication that load connected to normal power source

[] Indication that load connected to alternate source

NOTE: FOR AID IN SPECIFYING TRANSFER SWITCHES SEE EGSA STD. 100S.

9. Installation, Assembly and Testing

9.1 **Assembly Drawings and Wiring Diagrams --** Copies of installation drawings and complete wiring diagrams and interconnections shall be furnished to the architect/engineer.

9.2 **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 _______lb. per sq. ft. A suitable number of isolators shall be inserted between the engine generator set and the floor. Local codes may require specific type or degree of isolation.

9.3 **Ventilation Requirements --** The bidder shall submit with his submittal an estimate minimum 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 supported by manufacturer's data.

9.4 **Acceptance Test --** The extent of testing shall be at the discretion of the architect/engineer. The completed generator set shall be tested at 1.0 P.F. 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 architect/engineer before final acceptance.

APPENDIX - SUPPLEMENTARY INFORMATION

HOW TO SELECT ELECTRICAL COMPONENTS

In a generating system, the basic electrical components are the engine generator set and associated meters, controls and switchgear. Most installations include a single generator set designed to serve either all the normal electrical needs of a building or a limited emergency circuit. Sometimes the system includes two or more generators of different types and sizes, serving different types of loads. Two or more generators may be operated in parallel to serve the same load -- as when a building is being enlarged and requires added standby capacity.

The following information is designed to help in selecting the electrical components of a generator installation. No attempt has been made to cover every situation that might arise. Instead it's our purpose to suggest the areas in which a generator set may be effectively custom-tailored to user needs.

GENERATOR

With few exceptions, a generator set serves an alternating current load. Therefore, the typical generator is an AC generator -- or, as commonly called, an alternator or synchronous generator. In the following pages the words alternator, generator, and synchronous generator are used interchangeably.

When the generator is used as a standby system, the electrical output (that is, volts, wire, phase) must be compatible with the electrical system requirements.

The typical alternator has either a rotating field or rotary armature. the generator may have two bearings, with its rotor shaft connected to the engine by a flexible coupling or it may have only one bearing, with opposite end of the rotor shaft connected to the engine shaft by a pilot-type coupling. Either type is satisfactory for the sizes of generators commonly used in standby service.

Generator Rating

The rated capacity of a generator is the output obtainable when the generator is operated in accordance with its nameplate information. Ratings of generators used in engine-driven standby sets range from 25 kW up to almost any size.

Alternators normally are designed for 0.8 power factor loads. Generally it is less expensive and more satisfactory to adjust the load if necessary to make sure its power factor is at least 0.8 rather than to specify a special generator.

A generator is rated for a certain temperature rise, which is the difference between the ambient temperature and the average temperature in the generator windings. Unusual conditions of altitude, ambient temperature or ventilation may require either a larger generator to hold down winding temperature or special insulation to withstand higher temperatures. Generators operating in the tropics are apt to encounter excessive moisture, high temperature, fungus, vermin, etc., and may require special tropical insulation. See NEMA Std. MG1.

Speed and Frequency

An alternator operates at a single "synchronous" speed to produce a specified electrical frequency. The universal frequency in the United States an most of Canada is 60 hertz.

Frequency deviates briefly from standard when load is applied to or removed from the generator. If the load includes computers or other critical time-oriented equipment, such frequency deviations must be limited to a fraction of a percent. Frequency control is a function of the governor that controls speed of the engine.

Generators may be designed with 2 poles to run at 3600 RPM to produce 60 hertz or 3000 RPM to produce 50 hertz power; a 4 pole generator runs at 1800 RPM for 60 hertz and 1500 RPM for 50 hertz. A 6 pole machine would rotate at 1200 RPM to produce 60 hertz or at 1000 RPM for 50 hertz power.

Required Generator Capacity

The generator must have enough capacity to serve the largest total continuous load that it will be expected to carry. It also must have sufficient kVA capacity to start the largest motor without excessive voltage dip. (The extra current draw when a relatively large motor is started causes a momentary dip in generator voltage and frequency.) The generator size based on peak continuous is compared with the size of the generator required for motor starting and whichever is larger becomes the required generator size for the installation.

For some buildings, the maximum continuous generator load will be the total load when all equipment in the building is operating. For others, it may be more practical and economical to set up an emergency circuit or circuits so that only certain essential lights and equipment, and perhaps just one elevator, can be operated when the load is on the standby generator. In either case, if additional equipment is to be installed in the future, allowance for this added load should be made in computing the maximum continuous generator load.

The size of the generator required for motor starting can be determined from data or curves furnished by generator manufacturers. Knowing the maximum temporary voltage dip that is acceptable in the circuit, it is possible to select the size of generator that will be able to start a given size of motor without exceeding that voltage dip. If it is likely that two motors may start together, the sum of their horsepower ratings must be used as a basis for estimating motor starting requirements. If generators are pre-loaded, they are considered dynamically loaded and this fact should be taken into consideration when calculating subsequent load dips on motor starting or addition of other non-reactive loads.

Where quality of lighting is important, or where critical equipment is in operation -- in hospitals, laboratories or radio stations, for example -- voltage dip must be limited. Industrial plants, warehouses, gas stations and other places, where customers or workers are not as concerned with lighting quality, can accept much larger voltage dips.

Improving Voltage Dip and Recovery

If the generator size required to start the largest motor without excessive voltage dip is substantially larger than the size necessary to serve the maximum continuous load, consideration should be given to means of lessening the effects of motor starting. For example, the motor could have reduced voltage starting; motors could be powered by motor generator sets to cushion load changes; a high performance electronic voltage regulator could be incorporated with a PMG (permanent magnet generator) or a current boost in the standby generator to minimize the effect of voltage dips; the load could be divided between two generator sets, one for energizing critical circuits and the second for motors and other loads. The cost of such measures should be weighed against the cost of a larger generator set to determine the most practical choice.

Along with voltage dip, another factor that must be considered is ability to recover after the dip. Voltage recovery is affected by the extent of the dip and by the amount of load already on the line. If a motor is started under load and there already is a large amount of electrical load on the line, the voltage may not recover sufficiently after the initial dip to accelerate the motor or to hold in the starting contacts. Generator manufacturers furnish data that relate recovery voltage to voltage dip and the amount of other load already on the line.

Methods of overcoming a voltage recovery problem include starting the motor unloaded or using a reduced voltage starter. Another method is to keep other loads off the line until the largest motor is started. For this purpose, interlocks can be utilized in the motor starting circuits so that the motors can be started only in a certain sequence, with the largest motor being started first.
Specifying Generator Set Capacity

Whether generator size is controlled by maximum continuous load or by motor starting requirements, the minimum acceptable kW listed in the specifications should be based on the continuous load. If maximum continuous load is the controlling factor in determining generator size, the required kVA capacity will be 25% higher than the kW specification (at 0.8 P.F.). If generator size is based on motor starting conditions, the required kVA capacity may be something more than 25% above the minimum acceptable kW specification.

In the latter case, the generator may actually be nameplated for a higher kW capacity than shown. But the engine only has to provide enough power for the actual maximum continuous kW load. Therefore listing the actual kW load requirement avoids the extra cost of an engine that is larger than needed.

If it is expected that the generator will operate under continuous load at less than 0.8 power factor, this should also be specified. At lower power factor, the generator is less efficient, and this lower efficiency must be taken into account in computing the required size of engine.

Exciter

Included as part of the alternator package is an exciter which supplies direct current to the alternator field windings to magnetize the rotating poles. The exciter output may be controlled by a voltage regulator. thus, as alternator voltage varies, the voltage regulator causes the exciter to increase or decrease alternator field current to maintain rated voltage. Types of exciters are brush type with rotating commutator type exciters, static excitation, or brushless generator and exciter.

VOLTAGE REGULATOR

The voltage regulator holds the alternator output voltage at its rated value within a specified narrow range and, when load transients cause a change of voltage, it acts to return the voltage to this range as quickly as possible.

Most regulators operate indirectly by controlling current in the field of the exciter instead of the field of the alternator itself. When there is a sudden change in the load, causing a change in alternator voltage, the regulator senses this change and modifies the exciter field current to a level necessary for quick response. As the alternator voltage changes towards normal, the regulator acts to minimize output voltage -- overshoot or undershoot. See EGSA Std. 100R-1984 and 101P-1988.

Some types of voltage regulation systems are sensitive not only to voltage, but also to current output of the alternator. Under large load transients, when there is a rush of current through the alternator leads, a large current is automatically induced in the exciter field, greatly increasing its output to combat the voltage dip of the alternator. This feature is normally available as an option if not part of the standard design and is known as series or current boost option, short circuit current boost, or PMG (permanent magnet generator) any of which will support excitation during periods of fault or heavy motor loading rather than permit the output voltage to decay. This feature can be used for heavy motor starting or fault-clearing applications.

Types of Voltage Regulators

Mechanical regulators control exciter field current by adjusting resistance in the exciter field circuit in a variety of ways. Static regulators use electronic elements and bridge circuits to rectify and control the current in the exciter field. Some alternators are inherently regulated or self regulated and do not require a voltage regulator.

Stability and Regulation

Regulation is usually defined as the difference between no-load and full-load voltages divided by the full load voltage and expressed in percent. Stability is the ability to maintain or quickly recover to the steady state operating values after a change in the loading.

Voltage Transient Response

A regulator with sufficient response is required to minimize voltage dips or rises after load transients. In hospitals, for example, where light flicker must not occur and x-ray equipment would be affected by voltage variations, the engine generator set must be of sufficient size and design capability to minimize the effect of load transients. Most industrial applications can tolerate large voltage dips (up to 35% in some cases) as long as they are not so great as to cause motor contactors to drop out or automatic brakes to set. Additional consideration, however, must be given to the effects of voltage transients on computer and/or micro-processor based control equipment which may control the equipment in an industrial application.

However, fluorescent lights will not operate properly if voltage fluctuates more than 10% In addition, while many machines may not be affected by large voltage dips, the controls or instruments of these machines may be.

CONTROL PANEL

A generator usually has its essential meters in a control panel that may be mounted on the generator set or located remotely. A typical 60 hertz AC control cabinet contains:

AC voltmeter
AC ammeter
Voltage adjusting rheostats

The panel also may contain ammeter and voltmeter and selector switches to permit reading current or voltage in each of the phases; frequency meter and an elapsed time meter that indicates the total time the generator set has been operated. Engine instrumentation is frequently installed in this control panel.

When generators are operated in parallel there is a control panel for each generator, plus instrumentation for synchronizing the generators. See EGSA Std. 100G-1980.

PLANNING YOUR SYSTEM

A standby generator set may be started and switched onto the load manually, or it may incorporate controls that perform these functions automatically when there is an interruption in the normal power source. Most standby generator installations are automatic.

Manually controlled standby service is the simplest and lowest cost arrangement and may be satisfactory where an attendant is on duty at all times, and where automatic instantaneous starting and transfer of the load is not a critical requirement. A manually controlled system basically includes a manual switch for starting the engine and another for transferring the load to the standby generator and disconnects the normal power source after the generator reaches the correct voltage frequency.

In attended standby plants, and in any installation where even short power interruptions might be critical, an automatic starting and transfer switch is necessary. The system monitors the utility power supply and automatically starts the engine once there is a failure or severe voltage or frequency reduction in the normal supply. It automatically transfers the load as soon as the standby generator stabilizes at rated voltage and speed.

In hospitals, radio and television stations, and some industrial processing plants, an automatic system is necessary since a power interruption of more than a few moments might be serious. Other installations, such as refrigeration plants or industrial furnaces, can be protected by manually started standby generator sets if attendants are on duty 24 hours a day; but, if equipment is unattended overnight or on weekends, an automatic starting system must be used since a prolonged shutdown would be costly.

AUTOMATIC TRANSFER SWITCH

In the automatic transfer switch, relays connected to the normal power source cause the switch to act when the power fails or the voltage and/or frequency in any phase drops too low. First the relay closes contacts to start the engine of the standby generator set; then, when the generator has reached proper voltage and frequency, the switch is thrown automatically and transfers the load.

In most installations, the power failure relays act when the voltage in any phase of the normal source drops to 70% or less or the rated voltage. Automatic retransfer to the normal source occurs when the voltage on all phases of the normal supply is 90% or more. Radio, television, microwave systems, electronic equipment and some types of lighting cannot tolerate a voltage drop to 70%. For such applications, close differential relays are employed. Typically these relays are set to initiate action of the transfer switch when voltage in any phase drops to 90%, and to cause retransfer to the normal source when all phases are restored to at least 95%. If necessary, the differential between dropout and pickup may be set as close as 2%.

Close differential relays also should be used when there is a possibility that under open-phase conditions, terminal voltage will be sustained by the generator action of connected motors running lightly loaded. See EGSA Std. 100S-1988.

Automatic Transfer Switch Ratings

Automatic transfer switches are available in ratings from 30 amperes to 4000 amperes and up to 600 volts. Switches are rated for tungsten lamp, ballast, motor, resistive loads or combination thereof.

When an automatic switch transfers the load to the standby generator set, the switch is held in the emergency position either mechanically or magnetically.

When fault currents exceed the short time thermal capacity, additional consideration may have to be given to the withstand current rating of the transfer switch.

The design and application of the automatic transfer switch shall conform to the National Electrical Code and applicable local and state code requirements. In addition, the following standards shall be complied with when applicable for design, performance and inspection:

1. Industrial Type NEMA Standards - Publ. ICS-2-447-1970
2. Automatic Transfer Switches, Underwriters Std. UL-1008
3. EGSA Standard 100S 1988, Performance Standard For Transfer Switches For Use With Engine Generator Sets
4. CSA Standard C22.2 No. 178, Automatic Transfer Switches, Canadian Standards Assoc.

Main Switch and Circuit Breaker

Just as the incoming feeder lines of the normal power source usually are equipped with a disconnect switch and/or circuit breaker, the standby generator may have a main switch and/or circuit breaker that disconnects the generator from the load. The generator main switch and/or circuit breaker must be located in accordance with the prevailing code.

Exerciser

To keep the engine in good starting and running condition, and to make sure that the standby plant is operating properly, a programmed control should be added that starts the engine every few days and operates it for a set period of time. The control may be connected directly to the engine starting system, or it may be connected to the supervisory relays of the automatic transfer switch.

AUTOMATIC ENGINE STARTING CONTROLS

When the generator set is started automatically by the automatic transfer switch, certain starting and safety functions are incorporated in an automatic starting panel. The starting panel may also be used if desired, when the generator set is started manually. The starting control panel may be located on the wall or other stationary surface, or mounted on the standby generator set.

Cranking Control

When the manual starting switch is operated, or when the starting contacts are closed by the automatic transfer switch relays, the cranking of the engine is controlled by the automatic starting panel in a preset program.

Under extreme cold weather conditions, a long sustained cranking effort may be necessary to start the engine. If such conditions are anticipated, it may be desirable to use a timer that can be set for either one long cranking period or for several short ones. When the single cranking period is used, it should be at least 15 seconds long.

Safety Devices and Indicators

Since it might be injurious to the engine or to its cranking system if the cranking motor were engaged while the engine is running at high speed, the engine or the starting control must include some protective device that cuts out the starting circuit once the engine is running under its own power. this protection can be supplied by an oil pressure or fuel pressure switch or a speed operated device on the engine or by a crank disconnect relay on the starting panel.

Fault indicating lamps may be mounted on the starting control panel to indicate low oil pressure, high water temperature, overspeed condition, and fail to start (overcrank cutout). The starting control may also include a protective fuse and a reset pushbutton switch for resetting the controls after safety shutdown.

Switches

The automatic starting panel should be equipped with switches that (a) enable the engine to be started and tested manually, (b) cut out the starting circuit so the engine cannot be started either manually or automatically (as a safety precaution to prevent engine starting during maintenance), (c) test the automatic starting system. These functions can be provided by a 4-position selector switch located in the automatic starting panel. The positions of this switch are (1) "hand crank", (2) "stop" or "off", (3) "automatic" (the normal setting) and (4) "test".

When the switch is in the "manual" position, it bypasses the automatic starting panel's timing system and enables the engine to be started by the manual start/stop pushbutton the engine control panel. The "test" position is used to test the automatic starting control. When the switch is moved to this position, it closes the engine starting contacts and causes the automatic starting system to start the engine.

The above functions also may be provided by individual switches or by a 3-position selector switch ("manual", "off" and "automatic") plus a separate "test" pushbutton.

HOW TO SELECT ENGINE EQUIPMENT

As we know, an engine consumes air and fuel and expels exhaust gases. So the installation must include fuel supply, exhaust and cooling systems. And the generator set must be so located or arranged that the required supply of clean, cool air is made available to the engine. To maintain alternator output current
at precisely the correct frequency, the engine also requires starting equipment, protective devices and automatic speed control.

The following pages point out some of the engine equipment factors that must be considered when planning a generator set installation. Though no subject is treated exhaustively, we have tried to cover the important areas where selection of engine- related equipment can tailor the generator set to a specific set of needs.

LOCATION AND MOUNTING OF GENERATOR SET

The set may be located in the basement or on another floor of the building, in a penthouse on the roof, or even in a separate building. Usually it is located in the basement near the building heating plant with other equipment so it is convenient for operating personnel.

Since it is desirable that the generator set be located not too far from its fuel supply, regulations regarding fuel supply location may decide location of the generator set. Locating the unit near the building heating plant may make it possible for both to use fuel from the same supply.

The generator room itself should be large enough to provide adequate ventilation and plenty of working space around the engine and generator. The floor should be flat, level and capable of supporting the load. In addition, a method for safely expelling exhaust gases must be available.

Generator Set Mounting

Usually a generator set will be shipped assembled and merely needs to be set in place and leveled on the floor or foundation.

It is recommended that the generator set be mounted on vibration isolators or isolation pads to avoid transmission of vibration to surrounding structures and equipment.

Rubber or cork isolation pads may be used when vibration is slight. Steel springs in combination with rubber pads are used to combat both light and heavy vibrations. Other effects of engine vibration should be minimized by providing flexible connections between the engine and fuel lines, exhaust system, or other external systems.

Exhaust Piping

Engine exhaust must be directed to the outside through exhaust piping that extends through a wall or ceiling opening and may run up the outside of the wall to the roof. For both installation economy and operating efficiency, engine location should make the exhaust piping as short as possible with minimum bends and restrictions. The engine should be located so the exhaust system will not exceed the back pressure recommended by the engine manufacturer. Exhaust piping inside the building should be covered with lagging to protect personnel and to reduce room temperature and should be gas tight.

VENTILATION

An internal combustion engine requires a liberal supply of cool, clean air for combustion.

If the air entering the engine intake is of low density due to either or both high temperature or high altitude, the engine will not produce its rated power. Further adding to the problem is the fact that ordinary operation of the engine and generator results in convective heat transfer and radiation into the room. Therefore some means of permitting free flow of fresh air into the generator room is necessary to keep the environment reasonable for the engine and equipment, comfortable for personnel, and to make clean, cool intake air available to the engine and generator.

Where radiator cooling is used, the need is even greater, because this system requires significant quantities of cool air with low restriction to flow to do its job.

Though providing adequate ventilation seldom poses serious problems, it is an area that does not lend itself to generalizations or rules of thumb. Each installation must be analyzed by the generator set supplier and the customer on its own merits. It is only in this way that all the variables that are involved can be put into proper perspective.

The best advice to buyers is to be sure that the generator set supplier furnishes an accurate estimate of total air requirements for his unit.

With these thoughts in mind, the following paragraphs offer some tips that are usually helpful in providing good ventilation.

Room Size

First of all, the room should be of sufficient size to allow good distribution and free circulation of air. It is very desirable to have an opening to the outside or at least an opening to another part of the building through which air can travel. In smaller rooms, ducting can be used to bring air to the room or directly to the engine's air inlet.

Outside Ventilation

In addition, a ventilator with movable louvers should be mounted in the outside wall, preferably high up. The louvers can be gravity operated, but may have to be electrically operated if there is a possibility that wind would cause too great an air flow into the room. If the engine is radiator cooled, a wall ventilator usually is located in front of the radiator and serves as an exit for removing hot air and an additional ventilator is used for entry of fresh make-up air. If the radiator fan recirculates room air or expels the air through a duct, or if the engine has no radiator, the wall ventilator permits fresh make-up air to enter the room.

ENGINE COOLING

Air cooled engines are cooled by air being drawn directly across the engine and circulating up over the finned passages of the head and other parts of the engine, thus accomplishing cooling by direct convection only.

A liquid cooled engine is cooled by circulating the coolant liquid through passages in the engine. Hot coolant discharging from the engine may be piped or drained away, or more commonly, it is cooled and recirculated through the engine.

In the usual generator set, the engine coolant is cooled in a radiator by air that is blown through the radiator by a fan. Where there is a plentiful supply of clean water, a heat exchanger may be used instead of a radiator. The engine coolant circulates through the heat exchanger and is cooled by raw water from the ordinary building water supply or cooling tower flowing through adjacent passages in the exchanger. EGSA does not recommend usage of building water supply.

The advantages of a radiator cooling system is that it is self- contained and does not require any piping connections to the building. Many times when a storm or accident knocks out the normal power source, it also disrupts the water supply and would disable a generator set that is connected to the available water system. Therefore they are not recommended for standby service.
An air cooled engine requires no external means of cooling other than the air itself meeting self-contained needs.

Heat exchanger cooling is preferred if there is much foreign material in the air, such as lint or dust, that might clog the air passages of a radiator and cause the engine to overheat. If the generator room is small and has limited ventilation, a heat exchanger should be used.

Antifreeze Protection

If the engine is apt to be exposed to low temperatures, the coolant in the engine must be protected from freezing. In radiator cooled installations antifreeze may be added to the coolant to prevent freezing. For other types of cooling, antifreeze does only half the job. Some assurance must also be made that the water source does not freeze.

In addition to antifreeze, an electric immersion heater with an adjustable thermostat may be installed in the engine coolant system to maintain a constant temperature when the unit is not in operation. Heaters are available for operation on 110 volt or 220 volt alternating current and will maintain engine coolant temperature as recommended by the engine manufacturer.

The heater keeps the engine warm and makes it easier to start during cold weather. Such a heater should be considered mandatory in any critical installation, such as hospitals, requiring quick start and load acceptance.

SILENCING

Unmuffled engine noise is objectionable in most locations. So a silencer on the intake and a silencer on the exhaust are used to reduce engine noise to an acceptable level. The required degree of silencing depends on the location and may be regulated by law.

Exhaust Silencer

A silencer is attached to the exhaust system of the engine so that all of the exhaust gases must pass through it. The silencer reduces noise in the exhaust system by dissipating energy in chambers and baffle tubes and by eliminating wave reflection that causes resonance. The silencer should quiet only to the degree necessary since higher degrees of silencing require larger silencers.

Silencers come in various sizes and configurations to fit different sizes of exhaust system piping. The silencer should be selected to match the engine's noise signature and be compatible with the engine manufacturer's piping and size recommendations.

Types of Silencers

Silencers are rated according to their degree of silencing by such terms as "commercial", "moderate" or "semi-critical" and "high degree" or "critical".

Low Degree or Commercial Silencing -- Silencers are suitable for industrial areas where background noise level is relatively high or for remote areas where partly muffled noise is permissible.
Moderate Degree or Semi-Critical Silencing -- Reduces exhaust noise to an acceptable level in localities where effective but not complete silencing is required -- as semi-residential areas where some background noise is always present.

High-Degree or Critical Silencing -- Silencers provide maximum silencing for residential, hospital, school, hotel, store, apartment building and other critical areas where noise level must be kept to a minimum.

Silencer Installation

The silencer may be located close to the engine, with exhaust piping leading from the silencer to the outside; or the silencer may be located on the roof, with exhaust piping coming from the engine through the roof or up along the outside of the building wall. It is preferable to locate the silencer close to the engine, with minimum piping, for best overall noise attenuation and system performance, but it may, however, be more practical in some cases to locate the silencer on the roof -- especially a large, heavy silencer.

The silencer must fit into the space available without requiring extra bends in the exhaust piping, which would increase exhaust back pressure. Silencers should be protected from rain and snow and silencers or exhaust piping within reach of personnel should be covered with screening or lagging.

Intake Cleaner-Silencer

An intake silencer, per se, is not usually installed since an engine normally is supplied with at least one intake air cleaner that also serves as an intake silencer.

Air cleaners are rated as light, medium or heavy duty. For most indoor standby applications, a light-duty air cleaner is satisfactory. If the engine operates in a dusty atmosphere, it may require a medium or heavy-duty rated cleaner to provide adequate engine protection. An air restriction indicator may be used to indicate when filter is clogged to require cleaning or replacement.

For indoor installation the air intake of the cleaner-silencer should not be under an engine hood since warmer air reduces engine horsepower. Restriction of air flow also reduces horsepower. Therefore, if the air cleaners are mounted remote from the engine, the air piping to the engine must be large enough to permit the free flow of air without excessive restriction. The piping must be leakproof or the benefit of the air cleaner is lost. The air cleaner and piping, if supplied from a source other than the engine manufacturer, must be sized in accordance with the engine manufacturer's recommendations.

FUEL SUPPLY

Storage Tank Location

To simplify the fuel supply system, the fuel tank should be as close to the engine as possible. When gasoline or LP fuel are used, they normally cannot be stored in the same room with the engine because there is a danger of fire or fumes. When diesel fuel is used, many times it can be stored in the same room as the engine. However, the building code regulations and fire insurance requirements should be checked, to determine conformance of the fuel storage system.

Tank Capacity and Construction

The capacity of the main storage tank is based on the expected rate of fuel consumption and the number of hours of operation that must be possible between refills. To estimate fuel consumption, the manufacturer of the engine should be requested to provide fuel consumption data. Consult applicable codes for minimum size and construction.

Fuel tanks should never be made of galvanized steel because of the chemical reaction between the fuel oil and the galvanized coating which causes flakes to clog the system. In general, either steel or fiberglass construction is acceptable.

Fuel Deterioration

Gasoline and diesel fuels deteriorate if they stand unused for a period of many months. With standby generators it is preferable to store only enough fuel to support a few days or even a few hours of continuous running of the generator set so that normal engine testing will turn over a tankfull within a short period of time. However, inhibitors may be added to the fuel to obtain greater storage life. A gum inhibitor added to diesel fuel will keep it in good condition up to two years.

Diesel Fuel Transfer System

The fuel transfer system delivers fuel from the tank to the engine and returns the unused surplus to the tank for cooling. If the fuel storage tank is located within approximately 20 feet of the engine and less than 4 feet below the level of the engine fuel manifold, the storage tank can feed fuel directly to the engine by means of the engine's regular fuel pump. The fuel inlet restriction must be within the manufacturer's recommended limits for each engine. If the tank is from 4 to 12 feet below the engine, a high-lift transfer pump can be added to the engine to pump fuel from the storage tank. However, if the storage tank is located more than 20 feet from the engine or more than 12 feet below it, a smaller day tank must be located in the generator room to supply fuel to the engine.

Natural Gas

In some areas, engine generator sets may be furnished with engines that have been designed to burn natural gas. The gas supplier must be consulted for information on available gas pressure, quality and piping. Local codes must be consulted. A positive automatic shutoff device must be included in the supply line.

ENGINE SPEED GOVERNOR

Selection Method

To produce alternating current at a specified steady frequency, the alternator must rotate at constant speed for so-called synchronous speeds: for 60 hertz operation, 1200, 1800 and 3600 RPM are the usual synchronous speeds; for 50 hertz operation, 1000, 1500 and 3000 RPM are the usual synchronous speeds. The speed of the engine and alternator is controlled by a governor that automatically adjusts the engine fuel control as the load varies, increasing or decreasing engine power as necessary to maintain steady speed. When specifying a governor, it is usually best to set forth the exact minimum performance characteristics in terms of frequency control that you require for your unit under all load conditions. This gives the supplier the responsibility for selecting the correct governor to meet your needs. The following information is designed to provide the basis upon which a governor can be specified in terms of performance. See EGSA Standards 100E 1984 and 101P 1988.

Isochronous vs. Droop Speed Control

Governors are of two types -- "droop" and "isochronous". With a droop-type governor, the engine's speed is slightly higher at light loads than at heavy loads, while an isochronous governor maintains the same steady speed at any load up to full load. An isochronous governor thus has "zero-droop".

Speed droop is defined as a percentage difference between the normal steady speed or frequency at full load and that at no load. A typical speed droop is 3%. Thus, if speed and frequency at full load are 1800 RPM and 60 hertz at no load, they will be about 1854 RPM and 62 hertz. A droop-type governor usually is set so that it holds the desired nominal speed at full load.
Mechanical, hydraulic, electrical and hybrid governors are available to provide droop or isochronous speed control. Typically, they monitor speed directly on the engine (speed sensing) or as a function of the alternator frequency (load sensing). All types respond to an off-speed condition by causing an appropriate fuel change to restore the generator set to governed speed. Isochronous governors normally also provide a simple mechanical or electrical adjustment to provide speed droop.

An isochronous governor may be required when the load includes frequency sensitive equipment that may be affected adversely by slight frequency variations. To save cost, less expensive droop- type governors should be considered when isochronous regulation and tight frequency control are not required.

Stability and Frequency Regulation

Under steady load, frequency tends to vary slightly above and below the normal frequency setting of the governor. The extent of this variation is a measure of the stability of the governor. An isochronous governor maintains frequency stability with plus or minus 1/4%, while less sensitive governors permit frequency to vary with plus or minus 1/2% or more.

Transient Response

When load is added or removed, speed and frequency dip or rise momentarily before the governor causes the engine to settle at a steady speed at the new load. An isochronous governor responds more quickly and settles out faster than the usual droop-type governor so that frequency rise or dip during a low transient is very small and recovery to steady speed is rapid.

Parallel Generator Sets

When generator sets are paralleled, it is essential to make each unit carry its share of the load so no set will be overloaded when the plant approaches full load. When alternators operate in parallel, they are locked together in synchronism, which means that their frequencies are always equal whether they are sharing the load proportionately or not.

When two or more sets are paralleled at synchronous speed, the power delivered by each set to the common load is monitored directly or indirectly and the basic speed setting of the governor changes to share load proportionately within approximately 2 to 3%.

When two or more sets are paralleled by speed droop, they normally will share load proportionately within 10%.

ENGINE CRANK-START SYSTEMS

Types Available

Most generator sets utilize a battery-powered electric motor for engine starting. The motor is connected by cables to batteries of suitable voltage and ampere hour rating as recommended by the engine manufacturer. When the engine starting contacts are closed, either manually or by the automatic transfer switch, power from the batteries causes the motor to crank the engine until it starts or until a time limit in the automatic starting system stops the cycle.

Pneumatic and hydraulic systems are also available.

Batteries

The batteries of the electric starting system should be located as close to the cranking motor as possible to avoid the voltage drop caused by long leads, and they should be accessible for servicing. Usually they are mounted on the base of the generator set or in a separate rack next to the engine.

Batteries used for engines are suitable heavy-duty type with a minimum capacity as recommended by the manufacturer of the engine. Batteries of 6, 12 or 24 volts are adequate for starting most engines.

It may be useful to have some generator room lights powered by the engine batteries, especially if the set is to be started manually. the extra load of the lights must be taken into account in specifying battery capacity. See EGSA Std. 100B.

Battery Charger

On standby generators, the engine electric starting system must be equipped with a battery charger since batteries tend to lose charge over a period of time while the engine is not running. A battery charger converts an AC input to a DC output at the rated voltage of the batteries. It may be connected to the normal source of AC power only, or it may be paralleled with the load to permit charging from either the normal or the emergency source. In the former case, it only charges when the normal source is available and depends on the engine's battery-charging generator or alternator to restore the battery to full charge after the engine has started. In the latter arrangement, cost is saved since no engine battery charging generator or alternator is required.

Battery chargers are either automatic or non-automatic. One automatic type monitors the batteries periodically and charges briefly at a high rate to keep the batteries at full charge. Another automatic type charges at a high rate when any battery is below full charge, then maintains a continuous trickle charge on the battery. Non-automatic charges also maintain a trickle charge on the batteries and can be manually switched to a high charging rate when necessary. Usually an automatic charger is preferred for a standby generator set -- especially when the plant is unattended.

Chargers are generally available with one of the following outputs: 6, 12 or 24 volts DC. In most cases they have taps for several input voltages from 120 to 600 volts. A battery charger preferably should have an ammeter or voltmeter and a lamp to indicate operation, and its components should be protected by fuse or circuit breaker. See EGSA Std. 100C.

Cold Weather Starting Aids

If the engine is apt to be exposed to subfreezing temperatures, it may be necessary to utilize special starting aids to insure prompt starting in cold weather. Cold weather starting can be aided by using an immersion heater in the engine oil pan or water jacket. When specified, one of these heaters is furnished as a part of the engine assembly, and it is merely necessary to plug it into the building electrical circuit. The heater is thermostatically controlled and operates only as needed to keep the engine warm. These should be installed and operated in accordance with engine manufacturer's recommendations. If extreme cold weather conditions are to be expected, consult with the engine generator set manufacturer for additional recommendations.

ENGINE SAFETY ALARM SYSTEM

Dependent on local code requirements, an engine that loses oil pressure, overheats, or overspeeds, should be shut down to avoid damage. An automatic emergency alarm or shutdown system is available as an accessory on most engines. Depending on the needs of a particular installation, the emergency system may incorporate any or all of the following functions:

Automatic shutdown when the engine overspeeds.

Audible alarm or automatic shutdown or both when water temperature is too high.

Audible alarm or automatic shutdown, or both, when lubricating oil pressure is too low.

Preliminary warning system prior to actual shutdown.

The alarms or shutdowns that are necessary to safeguard the engine depend on the circumstances of each installation. For example, if an operator will be on hand whenever the engine is running, he may need nothing more than the water temperature gauge on the engine instrument panel as a warning of engine overheating. But a drop in lubricating oil pressure is more critical and should call for immediate action either by an audible alarm or automatic shutdown. If no one is apt to be in close attendance, automatic shutdown probably is essential for overheating, overspeeding and low oil pressure.

In any case, whenever an alarm or shutdown is incorporated in the system, it should include a warning light so that the operator can see what type of malfunction has occurred. Manual reset types of indicators are available.

If an operator is not regularly in the vicinity of the generator set or its control room, both audible alarm and automatic shutdown should be incorporated in the system. If it is not likely that an audible alarm in or near the generator room would be heard, a remote alarm and indicating light may be required at some central station in the building to indicate that the engine had shut down.

Such an indication may not be necessary when a single generator set is supplying power to the building, since an automatic shutdown would be obvious. But if the set is one of two or more operating in parallel, or if it is being exercised automatically when the shutdown occurs, an alarm or indicator at the main desk or other central station might be necessary to alert personnel that something has gone wrong.

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