PERFORMANCE STANDARD FOR

GOVERNORS ON ENGINE GENERATOR SETS

EGSA 100E, 1992

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1. SCOPE

This standard covers mechanical, hydraulic and electric governors used for controlling speed and/or loading of engine-driven generator systems. The system may involve a single unit or multiple units operating in parallel. It may serve as a prime or emergency standby power source. Operation may or may not be in conjunction with an external power bus.

2. REFERENCE STANDARDS.0 REFERENCE STANDARDS

MIL.-STD.-705 B	Frequency and voltage regulation, stability and transient response tests.
IEEE 100—1988	Standard Dictionary of Electrical and Electronic terms.
EGSA-101E—1984	Glossary of Standard Industry Terminology and Definitions, Electrical.
EGSA-101M—1984	Glossary of Standard Industry Terminology and Definitions, Mechanical.
EGSA-100M—1992	Performance Standard for Multiple Engine Generator Set Control Systems.

3. DEFINITIONS.0 DEFINITIONS

3.1 Speed Governing System.1 Speed Governing System:

A speed governing system consists of a speed governor and fuel metering device which controls the fuel supply to the engine. The speed governing system senses speed and perhaps load, and meters the engine fuel supply such that speed tends to remain constant or to vary with load in a predetermined manner.

3.1.1 **Speed Governor.** The speed governor includes those elements which are directly responsive to speed and/or load and which position or influence the action of a fuel metering device to maintain the operating speed. When operating in parallel with an independent power source such as the utility company, the governor will act to regulate load.

3.1.2 **Fuel Metering Device.** A fuel metering device is an element directly or indirectly positioned by the speed governor; e.g., variable displacement pumps, fuel metering pumps, carburetors and other devices that meter fuel into the combustion system.

3.1.3 **Speed Changer (Speed Setting Device).** A speed changer is an element by means of which the speed governing system can be adjusted to change the speed (frequency) of the generator set under conditions of single unit, isolated load operation, or to change the power output under conditions of parallel operation with an independent power source.

3.2 **Overspeed Protection System.2 Overspeed Protection System.** An overspeed protection system is a group of devices which sense speed and shut off fuel, ignition or air flow when the speed exceeds maximum speed. It should operate completely independently from the speed governing system. It should require manual reset before the engine can be restarted.

3.3 **Rated Speed.3 Rated Speed.** Rated speed is the speed of the prime mover output shaft which provides desired generator set frequency.

3.4 **Steady State Operating Conditions.4 Steady State Operating Conditions.** Steady state operating conditions exist when the engine generator unit is functioning without any influences that are variable; e.g., load changes, BTU of fuel, ambient air temperature or humidity.

3.5 **Steady State Speed.5 Steady State Speed.** Steady state speed is the mean governed speed when the engine generator unit is functioning with steady state operating conditions.

3.6 **Steady State Speed Band.6 Steady State Speed Band.** The steady state speed band is the magnitude of the variation in speed, excluding system influence, when the engine generator unit is operating isolated and under steady state conditions with a sustained load. It is expressed as a percentage of rated speed.

NOTE: When the total magnitude of variation in engine generator speed with the speed governing system inoperative is zero, the steady state speed band is a result of the speed governor and is used to determine the stability of the system.

NOTE: When the total magnitude of variation in engine generator speed with the speed governing system inoperative is not zero, the steady state speed band is not wholly produced by the speed governor and, therefore, may not be used in total magnitude to determine the stability of a system.

3.7 **Speed Regulation (Droop).7 Speed Regulation (Droop).** Speed regulation is the speed change with increase in power output of the prime mover. It is expressed as the percentage change in speed corresponding to the change from zero to full power output.

3.8 **Isochronous (Zero Droop) Speed Governing.8 Isochronous (Zero Droop) Speed Governing.** Isochronous speed governing is a method of controlling speed in which the steady state speed is independent of load or fuel control position. It may be thought of as a zero droop.

3.9 **Stall Torque of the Governor Output.9 Stall Torque of the Governor Output.** Stall torque is net torque produced by the speed governor mechanism in the increasing fuel direction to any given output position. Since the fuel control mechanism may be working against a restoring force (such as a spring) in the decreasing fuel direction, the stall torque rating is defined to be the resulting maximum net torque in the increasing fuel direction.

3.10 **Work.10 Work.** Work is the torque multiplied by the angular travel in radians if the governor output is rotary. It is force multiplied by linear distance traveled if the governor output is linear.

3.11 **Parallel Operation.11 Parallel Operation.** Parallel operation exists when an engine generator unit is operating with its generator connected to an electric power system in common with generators of other prime mover generator units. This subject is covered in detail in EGSA-100M—1992.

3.12 **Isochronous Load Sharing.12 Isochronous Load Sharing.** Isochronous load sharing is the ability of two or more governed systems loaded in parallel to share the load proportionally while operating isochronously.

3.13 **Speed Transient Response.13 Speed Transient Response.** Transient response is a measure of the change in speed of the generator set as a result of sudden changes in load, the magnitude of which should be specified. It is measured in percentage change in generator frequency or speed as the result of specified load changes. A typical specification for a naturally aspirated system might be in the range of 2-6% frequency change as the result of a 100% change in load, depending upon system factors (Ref. Section 5.3).

3.14 **Recovery Time.14 Recovery Time.** Recovery time is the time required for the engine generator frequency or speed to recover to within the specified steady state speed band as a result of a specified change in load (Ref. Section 5.3).

4. CLASSIFICATION OF GOVERNORS.0 CLASSIFICATION OF GOVERNORS

Governors will fall into one of four classifications:

4.1 **Mechanical Governor.1 Mechanical Governor.** A purely mechanical speed governing system. The speed is mechanically sensed and governed from a rotating output of the prime mover. In addition, the work to control the fuel metering device is derived from this rotational output.

4.2 **Hydraulic Governor.2 Hydraulic Governor.** A hydraulic governor is similar to the mechanical governor (Ref. Section 4.1) in the means of sensing and governing speed; however, the work from the fuel control mechanism is produced by control of a pressurized hydraulic source.

4.3 **Electro-Hydraulic Governor.3 Electro-Hydraulic Governor.** An electro-hydraulic governor is a system in which the prime mover speed is electrically sensed. The output force of the electro-hydraulic actuator, however, is hydraulic in nature much the same as the hydraulic governor (Ref. Section 4.2). An electrical command from the speed governor circuit determines the output position of the actuator.

4.4 **Electronic Governor.4 Electronic Governor.** An electronic governor is a system in which the prime mover speed is electrically sensed and governed. The output force for the actuator is entirely electro-magnetic. The output force is dependent on an outside source of electrical energy, such as a storage battery.

4.5 **Isochronous Load Sharing.5 Isochronous Load Sharing.** Isochronous load sharing is a system which monitors the power output of a given engine generator and modulates the fuel to the engine so as to produce equal or proportionate load sharing with respect to one or more other generator sets connected to the same electrical power bus. The generator bus frequency is isochronous (Ref. Section 3.8), i.e., independent of load.

4.6 **Droop Load Sharing.6 Droop Load Sharing.** Droop load sharing is load sharing based upon an engine generator which has a predetermined speed droop or regulation characteristic, (Ref.

Sections 3.6 and 3.7) which is operating in parallel with one or more generator sets on the same electrical bus. The power output of each unit is determined by bus frequency, the respective engine generator speed setting and the droop or regulation setting.

To obtain proportional load sharing, the droop or regulation of each unit should be identical to the others. In practice, using droop load sharing, load can be expected to be proportionately shared within 20% of the respective kW ratings.

5. APPLICATIONS.0 APPLICATIONS

All generator sets must be equipped with a governor system to maintain the frequency of the generator output within acceptable limits. The degree of accuracy varies with the application and is the option of the purchaser. The governor used will be determined by the accuracy limits, the loading characteristics, the extent and duration of load excursions, the need for parallel operation, the degree of automation required, and the capital available for the installation.

5.1 If the load consists of normal lighting, heating elements and motors, and the unit is never expected to run in parallel, a simple governor capable of 5% regulation is generally considered sufficient.

5.2 If there are power demands requiring better than 5% regulation, these requirements should be specified. Typical requirements of modern business, commercial and communication applications would be for steady state speed band of ±.25 of 1%. Examples of power needs requiring such control accuracy would be clock accuracy, computers, video tape, and some motion picturing lighting needs.

5.3 Generator set response is determined by the governor time constant; WR^2 of the engine, generator, flywheel and coupling combination; and turbocharger characteristics. The non-linearity of the turbo-charger makes predicting transient response difficult. A governor may have a typical response rating but this is based on acceleration rate of the set, typically 50% per second with a naturally aspirated engine. When specifying transient response and recovery time, the governor manufacturer should be consulted.

5.4 If the generator set will become part of a multiple generator set installation, the governor must be capable of speed regulation to within the practical limits of the system to ensure accurate load sharing between the generator sets. Generally speaking, steady state speed band should be ±.25 of 1% of rated speed.

5.5 If isochronous load sharing between the units on a multiple generator set installation is required, load sensing governors described in Section 4.5 will be required.

5.6 For multiple generator set installations requiring load sharing but where speed regulation need not be better than 3 to 5%, droop load sharing may be permissible (Ref. Section 4.6). It is necessary to droop all generator sets identically. The operator is charged with controlling load distribution by adjusting the respective speed settings. This arrangement offers simplicity and lower cost but requires a greater degree of operator involvement.

5.7 Electro-hydraulic or electronic governors are best suited to automated controls as used in automatic starts, automatic parallel, automatic isochronous load sharing and automatic shutdown.

6. PERFORMANCE SPECIFICATIONS.0 PERFORMANCE SPECIFICATIONS

In selecting a governor system, a number of performance specifications are encountered. This section describes those parameters which affect system operation. At the end of this section are sample performance specifications encountered with mechanical or hydraulic, electro-hydraulic, and electronic governors.

6.1 **Operating Temperature.1 Operating Temperature.** Operating temperature is the range of ambient temperatures over which the governor system will operate satisfactorily and meet the other performance specifications. Operation beyond these limits may result in governor failure or excessive speed drift.

6.2 **Storage Temperature.2 Storage Temperature.** Storage temperature is the ambient temperature in which the governor system may be stored in a non-operating condition and not result in damage.

6.3 **Steady State Speed Band.3 Steady State Speed Band.** (See Section 3.6)

6.4 **Transient Response.4 Transient Response.** (See Section 3.13)

6.5 **Recovery Time.5 Recovery Time.** (See Section 3.14)

6.6 Sample Specification for a Mechanical or Hydraulic Governor.6 Sample Specification for a Mechanical or Hydraulic Governor:

Speed Setting Options (Select only those characteristics applicable.)
Manual:

Motor:

Pneumatic:

Output
Work Output:

Return Spring: (External or Internal)

Note: An external spring will derate output.

Performance

Steady State Speed Band:	±__________% rated speed (Refer to Application Section)
Typical Optimum Response:	____% offspeed with __ second recovery time with full load change on a ____%/second accel. engine. (Limited by total system response.)
Recommended Variable Speed Control Range:	From _____ to ______ RPM.
Regulation (Droop):	From _____% to _____%.

Operating Temperature:	Continuous operating temperature _____°F. _____°F. Ambient temperature _____°F. _____°F.

Hydraulic System Considerations
Oil:

Supply Pressure:

Flow at Normal Viscosity:

Filter:

Viscosity:

6.7 Sample Specification for an Electro-Hydraulic Governor (Single Unit).7 Sample Specification for an Electro-Hydraulic Governor (Single Unit):

Speed Range from _____ to _____ (RPM) (Hz)
Choose a range that includes the magnetic pickup frequency at rated speed.

$$\textit{MPU Frequency} = \frac{N \times RPM}{60}$$

Where N is the number of gear teeth.

Specifications (Inputs)

Speed Setting:	Internal or External
Switch:	Idle/Run User Selectable
Regulation (DROOP):	User Selectable

Power Supply

Source Voltage:	Not to exceed governor rating.

Adjustments

Low Idle Speed:	Sets idle speed from _____ to _____% or rated speed (User Selectable).
Rated Speed:	Potentiometer, sets rated speed.

Control Characteristics

Steady State Speed Band:	+______% of rated speed over temperature range.
Operating Temperature	_____°F to _____°F. _____°C to _____°C.

6.7.1 **Additional Considerations for Load Sharing:**

Inputs

Load Sensing:	Input signals must be compatible with load sharing equipment used.

Ramp Generator: Optional

Speed Trim: Allows external speed trim User selectable +____%.

Droop: Optional

Adjustments

Rated Speed: Sets prime mover rated speed.

Dynamic Response: Adjust for optimum system response.

Low Idle Speed: Sets prime mover idle speed from ____% to ____% or rated speed.

Load Gain: Calibrates control to CT ratio and allows load sharing stability adjustment.

Droop: Sets amount of droop from ___% to ___% CT currents of ____ of amps.

Control Characteristics

Load Sharing: Within ____% of rated load with speed setting matched.

6.7.2 **Additional Considerations for All-Electric (Electronic) Governor:**

Supply Voltage: (Specify) Nominal Battery ____ VDC

Minimum During Cranking ____ VDC

Maximum During Charging ____ VDC

Power Consumption: Steady-State ____ Watts
(Specified by governor manufacturer)
Peak ____ Watts

7. OPTIONAL ACCESSORIES.0 OPTIONAL ACCESSORIES

A speed governor system may be adapted to accomplish a number of other functions. These functions are normally performed by various accessories working in conjunction with the basic speed governor. They are as follows:

7.1 **Motor Actuated Speed Changer.1 Motor Actuated Speed Changer.** A motor actuated mechanism to be used for adjustment of the speed changer while the engine is in operation. This provides a means for remote speed control on hydraulic governors. With electro-hydraulic or electronic governors, it provides a controlled rate for speed or load changes.

7.2 **Ramp Generator.2 Ramp Generator.** A ramp generator is a device for controlling the rate of acceleration of the prime mover. It is often used to minimize smoke or control overshoot on acceleration to rated speed.

7.3 **Load Sensor.3 Load Sensor.** A load sensor is used with a basic electro-hydraulic or electronic speed governor to accomplish isochronous load sharing (Ref. Sections 4.5 and 5.5).

7.4 **Synchronizer.4 Synchronizer.** A synchronizer is a unit which accomplishes automatic frequency and phase matching by varying the speed setting on an engine generator unit prior to being paralleled to an external bus. It is used in multiple engine applications calling for automatic paralleling.

7.5 **Load Controller.5 Load Controller.** A load controller is a device which controls the loading of a single engine generator unit or generators paralleled to a common bus. It is used to control load to or from the common bus. It may be used in conjunction with a utility bus to determine the load assumed by the generator bus.

7.6 **Load Management Controller.6 Load Management Controller.** A load management controller device is applied to peak shaving and cogeneration systems to improve economy and efficiency. It is implemented in speed governing systems with load sensing capability where a local bus (composed of one or more paralleled engine generator units) is paralleled to an external bus. The load management control will govern and limit the power imported or exported to or from the external bus.

7.7 **Remote Speed Setting Potentiometers.7 Remote Speed Setting Potentiometers.** This potentiometer is used to trim or make minor frequency adjustments at a remote location. It is generally used for manual synchronizing or maintaining an accurate line frequency.

8. INSTALLATION.0 INSTALLATION

8.1 In a hydraulic governor, it is important to observe the manufacturer's recommendations to ensure optimum transient performance, control, stability and reliability. Where recommended, filters should be installed.

8.2 Linkage Between the Fuel Control Mechanism and the Fuel Metering Device:

To eliminate binding and friction, good quality ball joints should be used. If a connecting rod is used, it is important that a stiff enough rod be selected so as to prevent flexing and resultant dead band. However, where work from the fuel control mechanism is limited, the mass of the associated linkage should be reduced as much as possible to minimize the inertial load.

8.3 When using the electro-hydraulic or electronic governors, it may be necessary to shield critical wiring to the control to eliminate the possibility of external interference disrupting steady state speed control.

8.4 When the electronic governor is used, the length of the wire runs between the actuator and the speed governor should be minimized. Due to the higher current requirements, governor manufacturers will specify wire size and maximum lead length between the power source, speed control, and fuel control mechanism.

8.5 The electric governor consumes about the same amount of power as equivalent mechanical or hydraulic governors. The electric governor generally takes its power from the prime mover starting batteries. Care must be exercised to assure that the battery charger is capable of supplying enough power to replace all D.C. power used.

9. MAINTENANCE.0 MAINTENANCE

9.1 The manufacturer of the governor and/or the engine should provide a section within the operator's guide containing a maintenance program and schedule to meet the needs of each particular installation to ensure satisfactory performance and minimum down time. The program should include periodic testing, tightening connections and inspecting for evidence of overheating, excess wear and lack of lubrication in the linkage between the fuel control mechanism and the fuel valve.

9.2 It is highly recommended that only qualified personnel make adjustments to the governor.

9.3 Equipment supplied should not be disconnected or made inoperative as a means of expediting a repair. This is particularly true of protective devices. Qualified service personnel should be allowed to restore the system to its original operating condition.

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