PERFORMANCE STANDARD FOR

MULTIPLE ENGINE GENERATOR SET CONTROL SYSTEMS

EGSA 100M, 1992a

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PERFORMANCE STANDARD FOR MULTIPLE ENGINE GENERATOR SET CONTROL SYSTEMS

1. SCOPE

This performance standard describes equipment to control two or more engine generator sets operating in parallel. The system may use multiple engine generators in prime power or standby service. It may operate without or in conjunction with, but not parallel to, the electric utility and may range from a simple manual to a fully automatic operation.

2. REFERENCE STANDARDS

EGSA 101E-1984	Glossary of Standard Industry Terminology and Definitions
EGSA 101M-1984	Glossary of Standard Industry Terminology and Definitions
EGSA 101S-1988	Standard Specification for Standby Engine Generator Sets
EGSA 10OS-1989	Performance Standard for Transfer Switches
NEMA-ICS 1-1988	General Standard for Industrial Controls and Systems
NEMA-SG5-1990	Power Switchgear Assemblies
ANSI/IEEE C37 .20.1-1987	Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
IEEE 100-1988	IEEE Standard Dictionary of Electrical and Electronics Terms

3. DEFINITIONS

Reactive Load (var) Sharing. The process of regulating excitation which causes the reactive load to be shared proportionally between generator sets.

Real Load (Watt) Sharing. The process of governing which causes the real load to be shared proportionally between generator sets.

System. For this standard, the multiple engine generator set control system includes the controls to start, stop, protect, synchronize and parallel one or more engine generators with other generators or with an electric utility controls plus other related controls.

4. RATINGS

4.1 **Control Equipment.** The control equipment shall be rated for the control system dc or ac voltage, phase, frequency, and current capabilities required.

4.2 **Power Apparatus.** The power apparatus shall be rated for the power source system voltage, phase, frequency, current and interrupting capacity.

5. CLASSIFICATION

Paralleling systems may be classified by their mode of operation; manual or automatic.

5.1 **Manual Operation.** The operator monitors the voltave, frequency, and phase relationship on the incoming generator with respect to the common bus and manually initiates connection of the generator to the common bus when the conditions are acceptable.

5.2 **Automatic Operation.** Automatic controls monitor the voltage, frequency and phase relationship of the incoming generator with respect to the common bus. If the common bus is dead or if the conditions are acceptable, the control automatically connects the generator to the common bus.

6. APPLICATION

6.1 **Advantages.** Multiple engine generators, operated in parallel, are often desired over one larger set. Some of the reasons are:

6.1.1 **Reliability.** Reliability is inherently greater with multiple generator sets. A faulty unit can be serviced or repaired while others maintain power.

Note: Automatic load shedding control schemes should be considered if site load conditions require operating multiple units at high percentage levels. Failure of a running unit(s) in this case would cause overloading and possible failure of the remaining units, therefore causing power interruptions to the load.

6.1.2 **Economy.** Several smaller units may cost less than one larger unit. Smaller units are easier to ship and install at the job site. Smaller units may be run or shut down as a function of load demand to increase engine life and to maintain high fuel efficiency.

6.1.3 **Expansion.** Units may be added to an existing installation to provide system growth.

6.2 **Special Requirements.** Multiple engine generators, to be paralleled, must have compatible engine governors and generator regulators.

6.2.1 **Governors.** The governor controls the engine speed and directly affects the real load (watt) sharing characteristics. For satisfactory real load sharing, the governors must be either the isochronous load sharing type or an accurate speed droop type. The governor will typically hold steady state speed within ±.25%.

6.2.2 **Regulators.** The generator voltage regulator controls the generator excitation and directly affects the reactive load (var) sharing. For satisfactory reactive load sharing, the regulator must be equipped for paralleling and connected for compensation by either the droop or the differential (cross current) method. The regulator will typically hold steady state generator voltage with ±2%.

6.2.3 **Load Division.** The governor and the regulator will typically be capable of sharing the real and reactive loads within 10% of the nameplate rating of each individual engine generating set.

6.2.4 **Wave Form.** The system designer should be aware of the load characteristics, particularly their affect on waveform, to assure that the system sensors will respond only to legitimate conditions.

6.2.5 **Transient Response.** Control Power Supply. A reliable and stable power supply shall be provided to power the control system.

6.2.6 **Control Power Supply.** A reliable and stable power supply shall be provided to power the control system.

6.3 **Operation.** Manual or automatic multiple engine generator set paralleling controls accomplish he same end result but the reliability and time required to parallel varies from method to method. The following paragraphs briefly describe these paralleling methods.

6.3.1 **Manual Paralleling Operation.** The manual system requires a knowledgeable operator to bring each unit into synchronization. The ptriod.of time required to manually connect the incoming generator to the common bus is quite long when compared to the automatic paralleling operation.

6.3.2 **Automatic Paralleling Operation.** Automatic control equipment monitors the voltage, frequency, and phase relationship of the incoming generators with respect to the common bus. If the common bus is dead or if the conditions are acceptable, the controls automatically initiate connection of the generators to the common bus in a manner depending upon which paralleling system is used.

The following paragraphs describe two types of multiple engine-generator set paralleling control systems. They are random access, and fixed sequence paralleling. The specific application will dictate appropriate method of operation.

6.3.2.1 **Random Access Paralleling System.** This system automatically connects the "first ready" engine generator set to the common bus. Each engine generator in the multiple system is in an all out race to attain normal voltage and frequency for the "first ready" status. Simultaneous closure of 2 units to a dead bus must be precluded.

The first engine generator on the bus supplies the most critical loads. As other engine generators in the multiple generator set system attain operational status, the control system synchronizes and connects them to the common bus. The system very readily adapts to load priority schemes.

This system can provide the fastest in-service time with the highest reliability. It does this without a human operator and without depending on a specific engine generator to perform.

6.3.2.2 **Automatic Fixed-Sequence Paralleling System.** This system parallels the engine generator sets in a predetermined sequence. The control connects the first selected unit to a dead bus when voltage and frequency are adequate. If a bus is not dead, the control connects the first selected engine generator when synchronism is achieved. If required, the control connects the second unit, third unit, and so on as each unit comes up to speed and reaches the acceptable phase relationship. Automatic stopping sequences could include soft unloading of a unit (if governor controls have the capability), opening their output circuit breakers anu running the engines for a cooldown period before stopping.

7. EQUIPMENT

The various paralleling control systems require certain control function devices depending on their level of sophistication. Some devices that are standard on the automatic system are optional on the manual system. The following paragraphs list, and in some cases, describe some typical devices available.

7.1 **Paralleling Lamps.** Two clear sensed lamps are connected across two phases, on phase from the generated power and one phase of the common bus. These lamps will indicate phase sequence and phase relationship.

The preferred connection of the lamps will cause them both to go dark when the generated power and the bus power achieve synchronism.

7.2 **Synchroscope.** The synchroscope is used either with or instead of the paralleling lamps. It indicates the relationships between the phase and frequency of the generated power and the phase and frequency of the bus power.

7.3 **Synchrocheck Relay.** This device compares the phase angle, frequency and/or voltage of the generated power with that of the bus. It permits paralleling when the parameters of the generated power and the bus power are within tolerance.

7.4 **Automatic Synchronizer.** A control device that compares and adjusts phase angle frequency and/or voltage to that of the common bus.

7.5 **Reverse Power Relay.** This relay disconnects engine generator set when it draws power from rather than delivers power to the common bus.

7.6 **Voltage Adjusting Control.** This control adjusts generator output voltage.

7.7 **Speed Adjusting Control.** This control adjusts engine generator set speed.

7.8 **Voltmeter.** The voltmeter indicates the common bus voltage for comparison with the incoming generator voltage.

7.9 **Ammeter.** The ammeter indicates common bus or individual generator current.

7.10 **Voltmeter-Ammeter Selector Switch.** This switch selects one line or phase of the 3 phase system.

7.11 **Frequency Meter.** The frequency meter indicates common bus or individual generator frequency.

7.12 **Engine Running Time Meter.** This meter totalizes the engine running time for maintenance schedules and records.

7.13 **Varmeter.** The varmeter indicates the amount of reactive load.

7.14 **Power Factor Meter.** This meter indicates the power factor of the load on the common bus or the individual generator.

7.15 **Wattmeter.** This meter indicates the real load on the common bus or the individual generator.

7.16 **Main Circuit Breaker.** The main circuit breaker connects each generator to the common bus. It May be manual or electrically operated for manual paralleling. It must be electrically operated for automatic paralleling. It must have an electrically operated trip device to open under a reverse power or safety shutdown condition.

The interrupting capacity of the circuit breaker must be sized for the system to which it is paralleled. If the breaker is electrically operated, the closing time of the breaker must be considered.

7.17 **Overcurrent Device.** This device protects the equipment from prolonged overloading or instantaneous high current. A separate overcurrent device is used in conjunction with a circuit breaker when overcurrent devices are not an integral part of the circuit breaker or disconnect device. They may be equipped with voltage restraint devices to assure operation under short circuit condition.

7.18 **Differential Relay.** This relay protects the generator, bus, and circuit breaker from internal faults.

7.19 **Loss of Excitation Relay.** This relay protects the generator (and other connected generators) from operating under poor power factor conditions caused by a loss of excitation failure during parallel operation.

NOTE: The precision, use and accuracy of the various instruments and relays is dictated by the requirements of the specific application.

8. ENCLOSURES

Various enclosures are available to avoid dangerous contact with the power and control circuits and also to protect the equipment from the environment. This standard enclosure (NEMA Type 1) functions adequately in most locations. Enclosures are described in NEMA ICS-1 and SG5.

9. MAINTENANCE

A scheduled maintenance program established and practiced will reduce or eliminate unscheduled downtime. The program should include periodic testing, connection tightening, dust and dirt removal, and thorough inspection.

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