

Recommended Practice
for Installing

Generator Sets



Published by
National Electrical
Contractors Association



Jointly developed with
Electrical Generating
Systems Association



An American National Standard

NECA/EGSA 404–2000
Recommended Practice for
Installing Generator Sets

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**National Electrical
Contractors Association**



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Systems Association**



National Electrical Installation Standards™

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(This foreword is not a part of the standard)

Foreword

National Electrical Installation Standards™ are designed to improve communication among specifiers, purchasers, and suppliers of electrical construction services. They define a minimum baseline of quality and workmanship for installing electrical products and systems. *NEIS™* are intended to be referenced in contract documents for electrical construction projects. The following language is recommended:

Generator sets for on-site power generation shall be installed in accordance with NECA/EGSA 404-2000, *Recommended Practice for Installing Generator Sets* (ANSI).

Use of *NEIS™* is voluntary, and neither the National Electrical Contractors Association nor the Electrical Generating Systems Association assume any obligation or liability to users of this publication. Existence of a standard shall not preclude any member or non-member of either organization from specifying or using alternate construction methods permitted by applicable regulations.

This publication is intended to comply with the edition of the National Electrical Code® (NEC) in effect at the time of publication. Because they are quality standards, *NEIS* may in some instances go beyond the minimum safety requirements of the NEC. It is the responsibility of users of this publication to comply with state and local electrical codes when installing electrical products and systems.

Suggestions for revisions and improvements to this standard are welcome. They should be addressed to:

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Other *National Electrical Installation Standards™* provide additional guidance for installing particular types of electrical products and systems. A complete list of *NEIS* is included in Annex A.

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1. Scope

This recommended practice describes installation procedures for generator sets for on-site power generation. It does not include general design considerations for on-site power systems.

This recommended practice is intended to define what is meant by installing equipment in a “neat and workmanlike manner” as required by the National Electrical Code, Section 110-12. All information in this publication is intended to conform to the National Electrical Code® (ANSI/NFPA 70).

Installers should always follow the NEC, applicable state and local codes, manufacturers’ instructions, and project specifications when installing generator sets.

Only qualified persons familiar with the installation, construction, and operation of generator sets should perform the work described in this publication.

2. Lifting the Generator Set

2.1 Lifting Points

The mounting skid of each generator set normally includes four lifting points (holes or brackets) at the corners. These are used to attach the lifting apparatus.

Do not lift the generator set by the lifting eyes attached to the engine and/or alternator. These lifting eyes should only be used during assembly of the generator set and are not capable of supporting the entire weight of the assembly.

2.2 Four-Point Lifting Method

To maintain generator balance during lifting, the lifting apparatus should be attached to the four skid lifting points. In all cases, be sure that lifting components such as cables, chains, and spreader bars are properly sized for the weight of the generator set. In some cases, it may be necessary to remove protruding generator components (air cleaner, shrouding) to avoid damage by lifting cables.

2.2.1 Spreader bars

One method of lifting standby generator sets uses an apparatus of hooks and cables joined at a single rigging point. Spreader bars should be used to avoid damage to the set during the lifting procedure. The spreader bars should be slightly wider than the generator skid so the set is not damaged by lifting cables and only vertical force is applied to the skid while lifting (see Figure 1).

2.2.2 Bars through lifting holes

The generator set can also be lifted by placing bars through the skid lifting holes and attaching hooks to the ends of the bars. Be sure the bars are properly sized for the weight of the generator set. Spreader

bars should also be used with this method if lifting cables are in contact with the set.

2.2.3 Special lifting fixture

A specially designed lifting fixture is often used to lift larger generator sets. The fixture serves the same purpose as spreader bars and usually includes adjustable cables to adapt to different sizes of generators.

2.3 Lifting Generator Sets Equipped with Accessories

The following information applies to lifting generator sets equipped with weather housing, sound shield, or sub-base fuel tank.

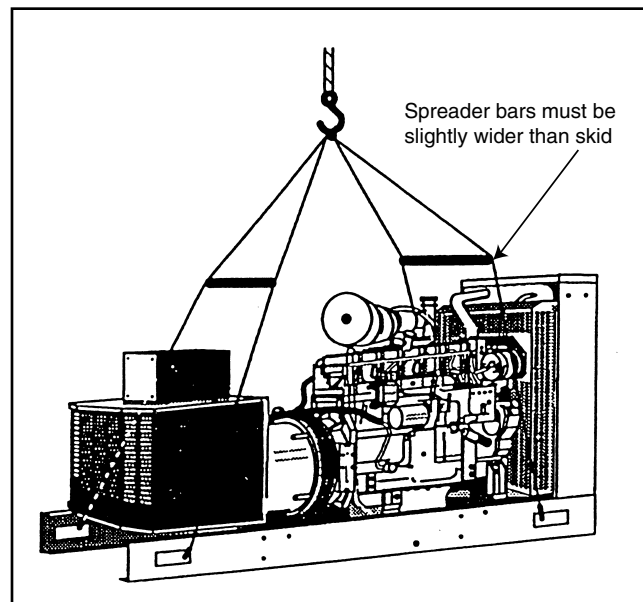


Figure 1

2.3.1 Weather Housing

Lift the weather housing and generator set together as one unit using the guidelines in 3.2.

2.3.2 Sound Shield

If the generator set has an installed sound shield and sub-base fuel tank, the entire assembly can be lifted as one unit. Make sure that the fuel tank has lifting eyes installed and does not extend beyond the perimeter of the generator set skid. In all other cases, remove the sound shield and follow this lifting procedure:

- a) Remove the sound shield, if installed, before lifting the generator set. The sound shield attaching bolts may be hidden by the sound shield insulation. To locate the hardware, carefully lift the sound insulation near the skid.
- b) Remove the wood skid before lifting the sound shield. Use the sound shield eye bolts, if so equipped, to lift only the sound shield.
- c) Reinstall the sound shield after lifting and mounting the generator set.

2.3.3 Sub-base Fuel Tank

- a) Lift the sub-base fuel tank separately if shipped separately from the generator set. Use lifting eyes if provided on the tank. Otherwise use chains, cables, or lifting straps to lift the sub-base fuel tank. If using lifting straps, protect the straps from sharp fuel tank edges.
- b) For generator assemblies rated up to 400 kW, lift the generator set and subbase fuel tank together, provided the fuel tank is empty and does not extend beyond the perimeter of the generator set skid.
- c) In all other cases, remove the mounting hardware and wiring between the generator set and sub-base fuel tank. Lift the generator set and fuel tank separately. (*NOTE: It is not necessary to drain the fuel tank when lifting just the tank by itself.*)

3. Generator Set Installation Procedures

Proper installation is essential to the proper operation of all generator set components. Thoroughly study associated instruction manuals, literature and drawings before attempting to install the generator set. In most cases, this information will already have been requested prior to the shipment of the generator set to enable advanced planning.

3.1 Location

The location of the generator set should comply with all applicable building codes and, at a minimum, the working space requirements of NEC Section 110-26. Consult the manufacturer's drawings to determine whether the generator set has special accessibility requirements.

3.2 Mounting

3.2.1 Slab floor

When a generator set is mounted on a concrete slab floor, a concrete pad should be poured on top of the floor. The pad should be reinforced concrete with a 28-day compressive strength of at least 2500 psi (173 kPa). It should be at least 6 inches (150 mm) deep and extend at least 6 inches (150 mm) beyond the skid on all sides. Type J bolts (sometimes called Type L bolts) should be used to anchor the skid or vibration isolators to the pad.

3.2.2 Sub-base fuel tank

When a generator set is to be mounted on a separately supplied sub-base fuel tank, install vibration isolators between the generator set and tank. It is recommended that the fuel tank be mounted so that an air space is provided between the bottom of the tank and the floor in order to reduce corrosion and permit visual inspections for leaks.

If the sub-base fuel tank is supplied as a unit with the generator set, follow the manufacturer's installation instructions.

3.2.3 Vibration isolators

Bolting a generator set directly to the floor or foundation will result in excessive noise and vibration and possible damage to the floor, and other equipment.

- a) Install vibration isolators supplied by the generator set manufacturer at locations shown on the generator shop drawings.

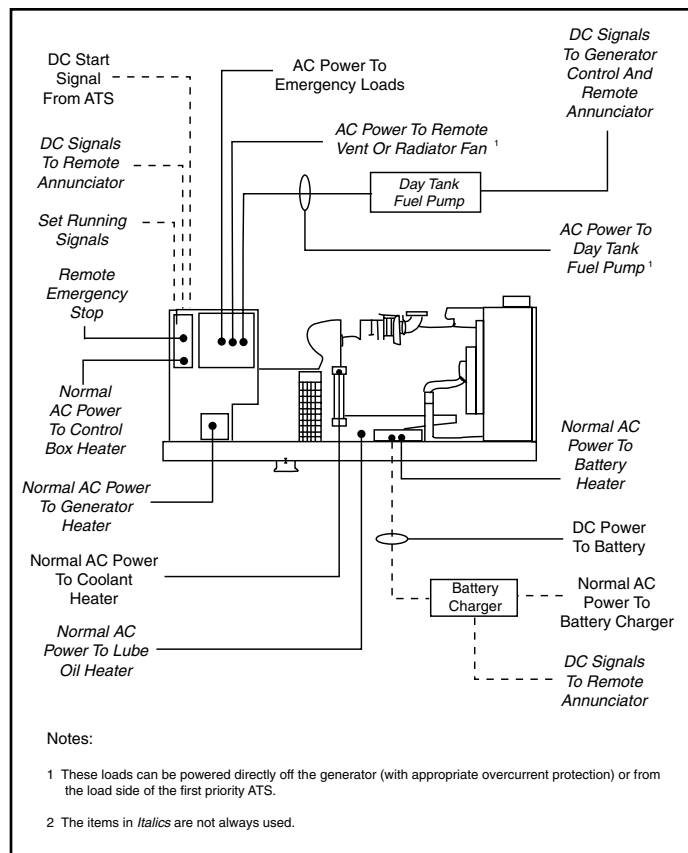


Figure 2

b) When the generator set is mounted on top of a separately supplied sub-base fuel tank, install vibration isolators between the generator set and the fuel tank.

3.2.4 Seismic vibration isolation

Carefully follow the plans and specifications when anchoring a generator set for seismic conditions. (NOTE: Local building codes may have seismic requirements that affect generator set installation. Installers should consult these codes or coordinate with the general contractor prior to installing generator sets.)

3.3 Electrical Connections

Figure 2 shows typical generator sets electrical connections. Not every unit has all the accessories shown.

3.3.1 Vibration isolation

Because of generator set motion on its vibration isolators, all wiring connections at the generator set

(power, grounding, control, and annunciating) should use stranded conductors installed in flexible metallic tubing, flexible metal conduit, or liquidtight flexible metal conduit at least 18 inches (460 mm) long.

3.3.2 Generator set AC output conductors (feeders)

a) No main circuit breaker (MCB). If no generator disconnect is required and the manufacturer includes a means of generator overload protection, connect feeders to the generator output terminals. The ampacity of the field-installed AC phase conductors from the generator output terminals to the first overcurrent device should be at least equal to 115 percent of the rated full-load current. See Figure 3(a).

b) Remote MCB. Some generator sets come with factory-supplied leads for connection to a separately-mounted remote main circuit breaker. When these leads have type CCXL insulation rated 125°C, they

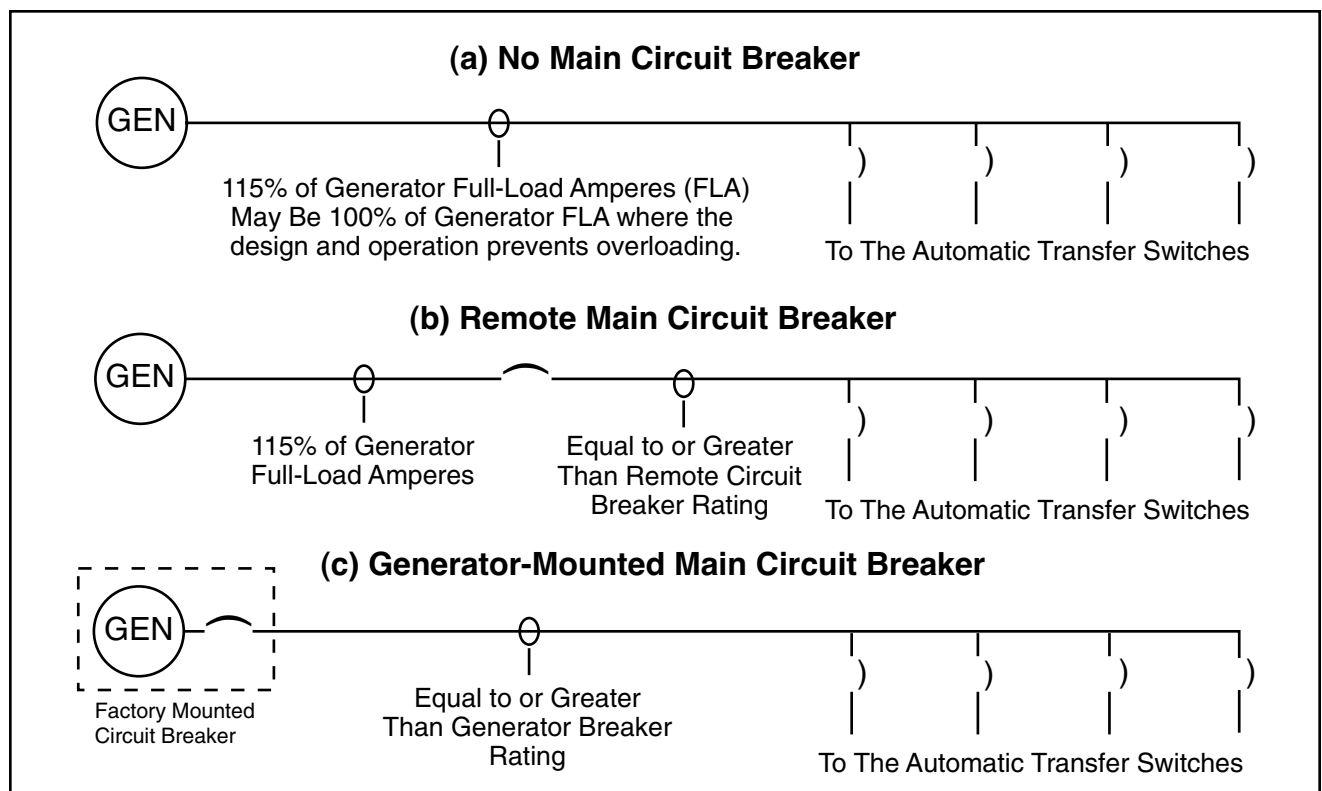


Figure 3

may be a smaller AWG size than would be required for field installation. See *Figure 3(b)*.

c) *Generator-mounted MCB.* If the generator set comes supplied with a factory-installed MCB mounted on the assembly, the ampacity of the field-installed AC phase conductors connected to the load terminals of the circuit breaker should be equal to or greater than the circuit breaker rating. See *Figure 3(c)*.

d) *Neutral ampacity.* The ampacity of the neutral conductor is generally permitted to be equal to or greater than the calculated maximum single-phase unbalance of the load. Where a significant portion of the load is non-linear, the neutral should be sized in accordance with the anticipated neutral current, including harmonics. A 200 percent-rated neutral conductor would be the maximum size required.

3.3.3 Grounding and bonding AC systems of 50 to 1000 volts

a) *Non-separately derived systems.* If the generator set neutral is solidly connected to a service-supplied system neutral (typically at the neutral block of a 3-pole transfer switch), then the NEC prohibits grounding the generator neutral at the generator set.

b) *Separately derived systems.* If the generator set is a separately-derived power source (i.e., it connects to the service-supplied power system at a 4-pole transfer switch), connect the generator neutral to a grounding electrode system using an appropriately-sized copper conductor (minimum No. 6 AWG).

c) *Generator sets used to supply emergency systems.* Where the grounded circuit conductor (neutral) connected to an emergency generator source is connected to a grounding electrode conductor at a location remote from the emergency generator, NEC Section 700-8(b) requires that there be a sign at the grounding location that identifies all emergency and normal sources connected to that location.

d) *Equipment grounding conductor.* A connection point for an equipment grounding conductor typically is located on the skid of the generator set, or

inside the main circuit breaker (MCB) enclosure. Connect the generator set to the grounding electrode system using an appropriately-sized copper conductor (minimum No. 6 AWG).

(NOTE: Flexible metallic tubing, flexible metal conduit, or liquidtight flexible metal conduit used to enclose power-feeder conductors should not be relied upon as a means for equipment grounding. Provide a separate copper equipment grounding conductor for all generator set installations.)

3.3.4 Control and alarm wiring

a) *Generator alarm.* If the generator set is equipped with a main disconnect device (circuit breaker or switch), it should be supervised and arranged to activate an alarm if the main disconnect trips.

b) *Separate raceways.* Install control and signal wiring, from the generator set to the transfer switch and remote annunciators, in separate raceway(s) from power conductors to minimize power circuit interference with control circuits.

3.3.5 Generator accessories

a) *Branch circuits for accessory equipment* that is necessary for operation of the generator set are fed either from the load terminals of an automatic transfer switch (ATS) or from the generator terminals. Examples of accessories include fuel pumps, coolant pumps for remote radiators, and motorized louvers for ventilation.

b) *Battery charger and coolant heater.* If the generator set is equipped with a battery charger and/or coolant heater (also called jacket water heater), these items should be powered from a normal power panelboard, not the ATS or generator output terminals.

c) *Battery.* Generator sets generally come equipped with battery racks or boxes, and cables. Purchase a battery of the type specified in the manufacturer's instructions.

3.4 Exhaust System

Design of generator set exhaust systems is outside the scope of this publication. Installation of exhaust systems should follow these guidelines:

a) *Vibration isolation.* Use flexible, corrugated stainless steel exhaust tubing at least 24 inches (610 mm) long connected to the engine exhaust outlet(s) to take up thermal expansion and generator set movement. Smaller sets that are bolted directly to the floor should be connected by corrugated stainless steel exhaust tubing at least 18 inches (460 mm) long. Do not use flexible tubing to form bends or to compensate for misaligned piping.

b) *Muffler.* To reduce corrosion due to condensate, the muffler should be installed as close as practical to the engine so that it heats up quickly. Support the muffler and exhaust piping by non-combustible hangers or supports, not by the engine exhaust outlet. Weight on the engine exhaust outlet can damage the engine exhaust manifold or reduce the life of a turbocharger.

c) *Piping size.* Exhaust system piping should be sized according to the engine manufacturer's recommendations, so as not to exceed exhaust restriction requirements. Generally, exhaust piping should not be smaller than the engine exhaust outlet.

d) *Thermal protection.* Exhaust piping and mufflers should be thermally insulated to prevent burns from accidental contact, prevent activation of fire detection devices and sprinklers, reduce corrosion due to condensate, and reduce the amount of heat radiated to the generator room. (*NOTE: Use of insulating materials on engine exhaust manifolds and turbocharger housings should follow manufacturer's recommendations to prevent dangerous overheating.*) Route exhaust piping at least 9 inches (230 mm) from combustible construction, and use approved thimbles where exhaust piping passes through combustible walls or ceilings.

e) *Thermal expansion.* Iron and steel exhaust pipe expands approximately 0.0076 inches per foot of pipe for every 100°F rise in exhaust gas temperature above ambient temperature (1.14 mm per meter per 100°C rise). Flexible, corrugated stainless steel tubing should be used to take up expansion in long, straight runs of pipe.

f) *Horizontal runs* of exhaust piping should slope downwards, away from the engine, to the out-of-doors or to a condensate trap.

g) *Termination.* Generator set exhaust systems normally terminate outside the building or other structure at a location where engine exhaust will disperse away from building air intakes. It is highly recommended that the exhaust system be carried up as high as practical on the downwind side of buildings and that it discharge straight up to maximize dispersal. Exhaust should also discharge on the radiator air discharge side of the building to reduce the likelihood of exhaust gases being drawn into the generator room with the ventilating air. A rain cap should be provided if the exhaust outlet points up.

h) *Special requirements.* Some building codes specify that the exhaust outlet must terminate at least 10 feet (3 meters) from the property line, 3 feet (1 meter) from an exterior wall or roof, 10 feet (3 meters) from openings into the building, and at least 10 feet (3 meters) above the adjoining grade.

i) *Single system.* A generator set should not be connected to an exhaust system serving other equipment, including other generator sets. Exhaust gas can damage idle equipment served by a common exhaust system.

3.5 Fuel Supply

Design of generator fuel supply systems is outside the scope of this publication. Installation of diesel or gaseous fuel supply systems should follow these guidelines. Due to fire and explosion hazards, gasoline powered generator sets are not normally used for indoor applications.

3.5.1 Diesel fuel supply

a) *Tank capacity.* The fuel supply tank should hold enough fuel to run the set for the prescribed number of hours (NFPA 110 Class designation) without refueling.

b) *Vibration isolation.* Use approved flexible fuel hose for connections at the engine to take up generator set movement and vibration.

c) *Diesel fuel lines* are typically black iron pipe or copper. Cast iron and aluminum pipe and fittings are not used because they are porous and can leak fuel. Do not use galvanized fuel lines, fittings and tanks because the galvanized coating is attacked by the sulfuric acid that forms when the sulfur in the fuel combines with tank condensate, resulting in debris that can clog fuel pumps and filters.

d) *Separate fuel return lines* should be provided to the day tank or supply tank for each generator set in a multiple-set installation, to prevent the return lines of idle sets from being pressurized.

e) *Return fuel* should be routed to main fuel tank where possible. If the installation requires that the return fuel must be routed to the day tank, use fuel coolers to avoid overheating of the fuel supply.

3.5.2 Gaseous fuel supply

a) *Regulator.* Most installations include a service gas pressure regulator. Building codes require that gas pressure be vented to the outdoors.

b) *Vibration isolation.* Use approved flexible fuel hose for connections at the engine to take up generator set movement and vibration.

c) *Shutoff valves.* Most building codes require both manual and electric (battery-powered) shutoff valves ahead of flexible fuel hoses. The manual valve should be of the indicating type.

d) *Filter.* A dry fuel filter should be installed in each line to protect the sensitive pressure regulating components and orifices downstream from harmful foreign substances carried along in the gas stream (rust, scale, etc.).

3.6 Air Requirements

Intake and exhaust air requirements for generator sets are specified by generator set manufacturers. Where manufacturer's instructions are not available, follow these general guidelines:

a) *Locations of air inlet and outlet.* Openings for intake and exhaust air should be located on opposite

walls of a building or similar structure, whenever possible. They should never be located on the same wall, to prevent recirculation of combustion or cooling air. When practical, the exhaust air outlet should be located on the downwind side of the building.

b) *Air outlet size.* The air outlet should be no smaller than the area of the radiator core.

c) *Air inlet size.* The air inlet should be no smaller than 150 percent of the area of the radiator core, unless a ventilation fan is used to force air into the room.

d) Inlet and outlet size modifications:

If LOUVERS are used, increase opening sizes calculated above by 50 percent.

If WINDOW SCREENS are used, increase opening sizes calculated above by 80 percent.

If FURNACE-TYPE FILTERS are used, increase opening sizes calculated above by 120 percent.

3.7 Clean-up

3.7.1 Generator set clean-up

a) Vacuum all scrap, wire, dust and other debris from the generator and associated equipment. Do not use compressed air to blow debris out of the generator, since debris may, instead, settle inside devices and impair their ability to function.

b) Replace all parts and covers. Check for any pinched wires and close all doors. Make sure the enclosure parts are properly aligned and fastened securely.

3.7.2 Site clean-up

a) Depending on terms of contract, clean site as required.

b) When recycling options are available at the job site, separate used packing materials by type and recycle them.

- c) Dispose of non-recyclable packing materials appropriately.

3.8 Punchlist and Acceptance

- a) Walk through and assure completeness of project and clean-up.
- b) Note minor defects.
- c) Touch-up and repair all defects.
- d) Acceptance testing is normally performed by the generator set distributor. See 4.4.
- e) Turn project over to owner or general contractor, as required by contract.

3.9 Spare Parts

Turn over all spare parts, and a set of special tools and manuals where required for generator adjustments or tamper-proof hardware, to the owner or general contractor. Obtain a delivery receipt.

4. Energizing and Testing the Generator Set

Hazards exist in energizing a generator set, and this should only be performed by qualified electrical personnel. If a short-circuit or ground-fault condition exists caused by damage or poor installation practices, and this is not detected and corrected during the checkout procedures, serious personal injury and/or damage to the generator set can result when the generator set is first energized.

Generator set manufacturers' instructions typically specify procedures to be followed when energizing a generator set for the first time. If such instructions are not available, follow these general guidelines:

4.1 Pre-Energizing Procedures

- a) *Power connections.* Check all field installed power cable and bus bar connections for correct torque value.
- b) *Grounding and bonding.* Check the generator set equipment grounding conductor electrode connection, bonding connections, and system grounded conductor (neutral).
- c) *Clearances.* Check to insure that dents or other damage to the enclosure have not resulted in clearances that violate NEC requirements, or will interfere with moving parts.
- d) *Packing materials.* Remove foam blocks, packing material, and temporary cushioning from the generator and associated components.
- e) *Miscellaneous.* Check all relays, meters, and instrumentation device wiring and terminations.
- f) *Engine check.*

1. Check radiator coolant and lubricating oil levels, and add additional fluids if needed.

Inspect the radiator and coolant hoses for leaks; leaking or damaged hoses should be re-tightened or replaced as required.

2. Check drive belts to ensure they are in good condition and properly tensioned; adjust or replace as necessary.
3. Check engine mounting bolts for tightness; re-tighten if necessary.

4.2 Starting Engine for the First Time

- a) Prime the diesel fuel system, if required, using a manual or electric priming pump.
- b) Press the starter switch. If the engine fails to start within 30 seconds, release the starter switch and allow the starting motor to cool for two minutes before trying again. If the engine fails to start after four attempts, conduct an inspection to determine the cause.

4.3 Performance Testing

For routine operational checks and load tests, run the engine at no load for about five minutes to warm up. Then, apply a load equal to or greater than 35 percent of the generator nameplate rating. The unit should then be operated until temperatures stabilize. Refer to EGSA 101P for definition of generator set performance.

4.4 Acceptance Testing

Acceptance testing is normally performed by the generator set distributor.

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(This annex is not part of the standard)

Annex A: Reference Standards

This publication, when used in conjunction with the National Electrical Code and generator manufacturers' literature, provides sufficient information to install and maintain generator sets. The following publications may also provide useful information:

National Fire Protection Association
1 Batterymarch Park
P.O. Box 9101
Quincy, MA 02269-9101
(617) 770-3000 tel
(617) 770-3500 fax
www.nfpa.org

NFPA 70-1999, *National Electrical Code* (ANSI)

NFPA 110-1999, *Emergency and Standby Power Systems* (ANSI)

Electrical Generating Systems
Association
1650 South Dixie Highway, Fifth Floor
Boca Raton, FL 33432
(561) 750-5575 tel
(561) 395-8557 fax
www.egsa.org

EGSA 101P, *Performance Standard for Engine Driven Generator Sets*

EGSA 107T, *Test Methods for Engine Driven Generating Sets*

National Electrical Manufacturers
Association
1700 North Thirteenth Street, Suite 1847
Rosslyn, VA 22209
(703) 841-3200 tel
(703) 841-3300 fax
www.nema.org

MG 2-1989 (R1994), *Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators*

Institute of Electrical and Electronics
Engineers, Inc.
445 Hoes Lane
P.O. Box 1331
Piscataway, NJ 08855-1331
(800) 678-4333 tel
(908) 981-9667 fax
www.ieee.org

IEEE 446-1995, *Recommended Practice for Emergency and Standby Power Systems* (ANSI)

InterNational Electrical Testing
Association
106 Stone Street
P.O. Box 678
Morrison, CO 80465
(303) 697-8441 tel
(303) 697-8431 fax
www.netaworld.org

NETA ATS99, *Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems*

**Other *National Electrical Installation Standards*[™]
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www.neca-neis.org

NECA 100-1999, *Symbols for Electrical Construction Drawings* (ANSI)

NECA/FOA 301-1997, *Standard for Installing and Testing Fiber Optic Cables*

NECA 400-1998, *Recommended Practice for Installing and Maintaining Switchboards* (ANSI)

NECA 402-2000, *Recommended Practice for Installing and Maintaining Motor Control Centers*

NECA/IESNA 500-1998, *Recommended Practice for Installing Indoor Commercial Lighting Systems* (ANSI)

NECA/IESNA 502-1999, *Recommended Practice for Installing Industrial Lighting Systems* (ANSI)

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