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SUBJECT 2201

**OUTLINE OF INVESTIGATION
FOR
PORTABLE ENGINE-GENERATOR ASSEMBLIES**

Issue Number: 3

MARCH 2, 2007

Summary of Topics

This is the third issue of the Outline of Investigation for Portable Engine-Generator Assemblies. This new issue of Subject 2201 is being published in order to correct previously revised Figure 42.4 and Figure 42.5 in accordance with new labels to warn consumers of carbon monoxide (CO) poisoning.

The UL Foreword is no longer located within the UL Outline of Investigation. For information concerning the use and application of the requirements contained in this Outline of Investigation, the current version of the UL Foreword is located on ULStandardsInfoNet at: <http://ulstandardsinfo.net.ul.com/ulforeword.html>.

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INTRODUCTION

1 Scope

1.1 These requirements address the electric shock, carbon monoxide (CO), fire, and casualty aspects associated with the mechanical performance and the electrical features of portable engine-driven generator assemblies.

1.2 These requirements cover internal combustion engine-driven generators rated 15 kilowatts or less, 250 volts or less, which are provided only with receptacle outlets for the AC output circuits. The generators may incorporate alternating or direct current generator sections for supplying energy to battery charging circuits.

1.3 Generators covered by this outline of investigation are normally used by persons other than service personnel.

1.4 These requirements cover open ventilated generators having ventilating openings that permit the passage of external cooling air over or around the windings, or both.

1.5 These requirements cover generator components and combinations of such components.

1.6 These requirements do not cover generators for use in hazardous locations as defined in the National Electrical Code, NFPA 70.

1.7 These requirements do not cover generators for marine use. That equipment is covered by the Standard for Marine Electric Motors and Generators, UL 1112.

1.8 These requirements do not cover generators intended for installation in recreational vehicles. That equipment is covered by the Standard for Engine-Generator Assemblies for Use in Recreational Vehicles, UL 1248.

1.9 These requirements do not cover generators intended for stationary use. That equipment is covered by the Standard for Stationary Engine Generator Assemblies, UL 2200.

2 General

2.1 Units of measurement

2.1.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

2.2 Undated references

2.2.1 Any undated reference to a code or standard appearing in the requirements of this outline of investigation shall be interpreted as referring to the latest edition of that code or standard.

3 Glossary

3.1 The terms "generator," "unit," and "product," as used in this outline of investigation, refer to any equipment covered by this outline. For the purpose of this outline of investigation, the definitions in 3.2 – 3.18 apply.

3.2 BATTERY CHARGING CIRCUIT – A nominally 12V DC circuit intended only for charging the generator starting battery with peak voltage below 42V.

3.3 CARRYING/TRANSPORT POSITION – The position of the generator as it is being moved.

3.4 DIRECT CURRENT (DC) – A voltage or current waveform in which the instantaneous value does not vary.

3.5 ENCLOSURE – That portion of a unit that:

- a) Reduces the accessibility of a part that involves a risk of fire, electric shock or injury to persons, or
- b) Reduces the risk of propagation of flame, sparks, and molten metal initiated by an electrical disturbance occurring within.

3.6 GUARD – A part that reduces the risk of access to a component that has the potential of causing an injury to persons.

3.7 LIVE PART – Denotes metal or a conductive part within the unit that during intended use involves a risk of electric shock.

3.8 LOW-VOLTAGE LIMITED-ENERGY (LVLE) CIRCUIT – A circuit with an open-circuit potential of not more than 21.2 volts peak AC, or 30 volts DC, with the energy available to the circuit limited:

- a) So that the current under any condition of load including short circuit is not more than 8 amperes for potentials up to 21.2 volts peak, and measured after 1 minute of operation by:
 - 1) Inherent design of the engine.
 - 2) A fixed impedance or reliable regulating network; or
- b) By a fuse or nonadjustable manually reset circuit protective device that is rated or set at not more than the value specified in Table 12.1.

3.9 PORTABLE – A generator in accordance with the Scope, Section 1, which is intended to be moved for temporary use and is not intended for permanent stationary installation.

3.10 PROTECTIVE FRAME – The box outline of the frame structure of the generator.

3.11 PULSATING DIRECT CURRENT (DC) – A direct current (DC) that changes in value at regular or irregular intervals.

3.12 RATED OUTPUT – The maximum continuous amps, watts or kilowatts, or volt-amps or kilo-volt-amps that are declared with a marking by the manufacturer and that the machine is capable of sustaining continuously. It is determined after a suitable engine run-in period with a dry barometer of 99 kPa (29.31 in Hg) and at a temperature of 30°C (86°F).

3.13 RISK OF ELECTRIC SHOCK – A risk of electric shock is considered to exist if the voltage between parts exceeds the value specified in Electric Shock, Section 11.

3.14 SERVICE PERSONNEL – Persons having technical training and experience required to be aware of the risks encountered when performing a task and the measures to be taken to minimize the risks to themselves and other persons.

3.15 TOOL – A screwdriver, coin, key, or any other object that is used to operate a screw, latch, or similar fastening means.

3.16 USER – Any person other than service personnel who may not recognize potential danger associated with the use of a generator.

3.17 VOLTAGE OR VOLTS – An electrical potential. Unless otherwise noted, “voltage” or “volts” as used in this outline of investigation refers to the root mean square (rms) measurement of alternating current (AC) voltage.

3.18 WEATHERPROOF GENERATOR – A unit shown by test to be resistant to the effects of rain, corrosion, and ultraviolet exposure.

4 Components

4.1 A part or assembly component of a product covered by this outline of investigation shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this outline.

4.2 A component shall be used in accordance with its rating established for the intended conditions of use.

4.3 If the manufacturer assigns a rating or an intended use to a component of a generator (for example, an integral auxiliary switch intended to control an external circuit) the component shall be evaluated for that rating or use or both.

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5 Instructions and Drawings

5.1 Operating instructions in accordance with the requirements of Instruction Manual, Section 43, shall be furnished with each product.

CONSTRUCTION

6 Protection Against Personal Injury

6.1 Enclosures and guards

6.1.1 General

6.1.1.1 Hazardous moving parts shall be guarded so as to adequately reduce the risk of injury to persons during normal operation, setting of any adjustments, and maintenance of the product.

6.1.1.2 The following factors shall be considered in judging whether guarding for hazardous moving parts is adequate:

- a) Degree of exposure to the moving part,
- b) Sharpness, speed, and mass of the moving part, and
- c) Likelihood of accidental contact or entanglement with fingers, arms, feet, or clothing with the moving part.

6.1.1.3 Features of guards to be considered include:

- a) Removability of the guard with the use of tools.
- b) Removability for servicing and the need for replacement.
- c) Strength and rigidity.
- d) Completeness.
- e) Creation of risks of personal injury, such as pinch points, and the necessity for additional handling because of increased need for servicing (such as cleaning).

6.1.1.4 An opening in a guard or enclosure for hazardous live parts shall not permit the probe illustrated in Figure 6.1 to contact the part when inserted through the opening with a force of 1 pound (4.4 N) to its maximum depth and in a straight or articulated position.

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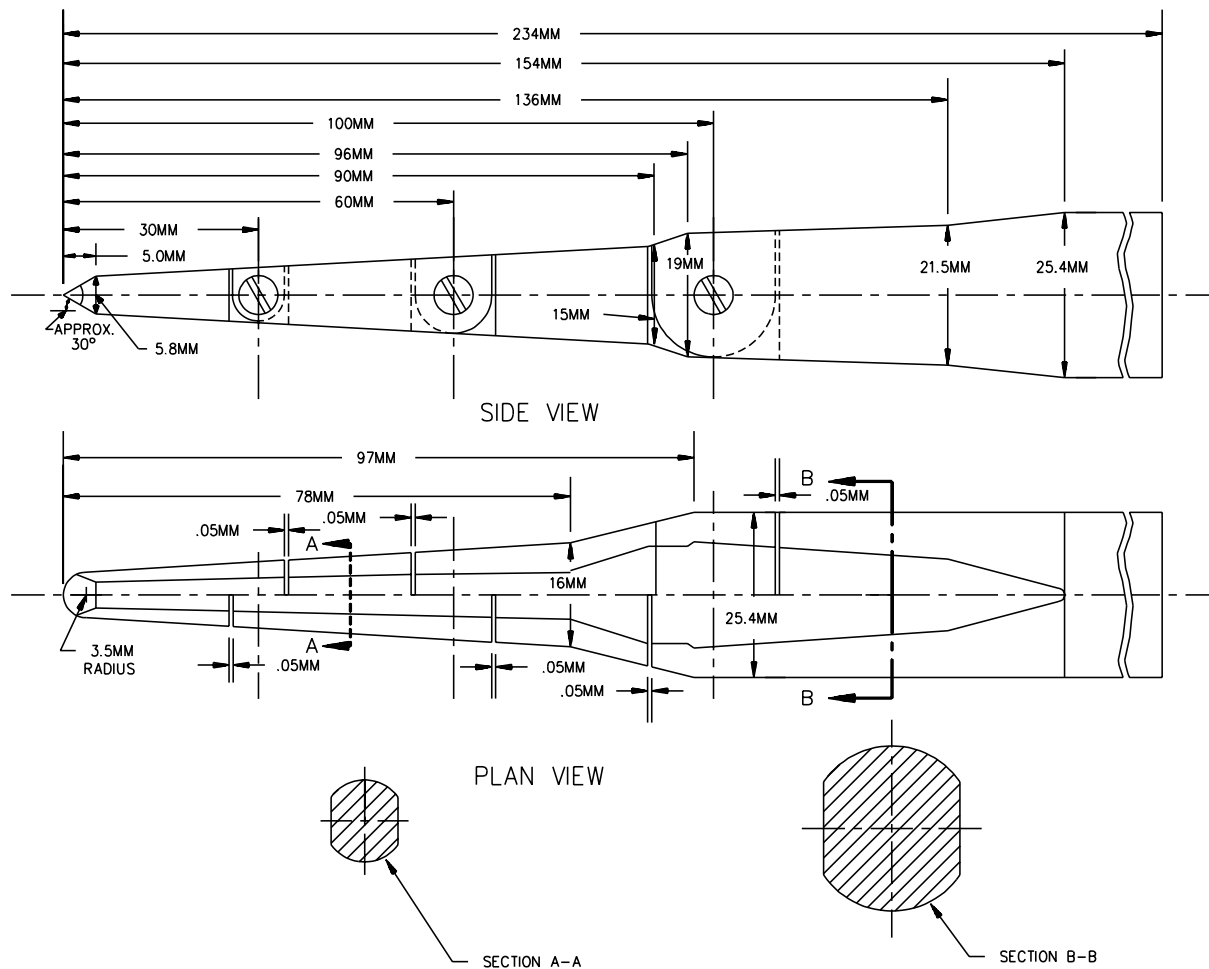
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Figure 6.1
Articulated probe



PA100

Probe available from Underwriters Laboratories Inc.

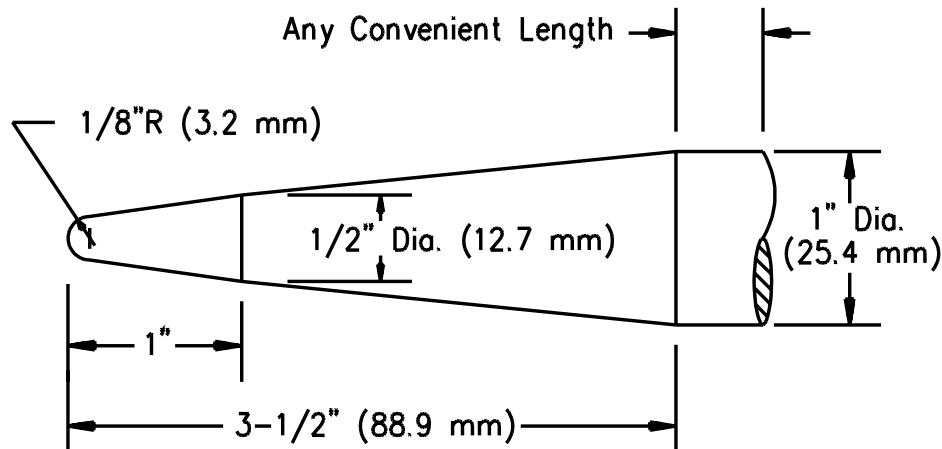
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6.1.1.5 The hazardous portion of all moving parts shall be so guarded that the probe illustrated in Figure 6.2 will not contact a hazardous part when inserted through any opening in the guard and applied with a force of 1 pound (4.4 N).

Figure 6.2
Fan probe



PA 160

6.1.2 Protection against corrosion

6.1.2.1 Parts formed of iron or steel and functioning as guard or enclosure for hazardous parts or acting as load supporting components where their failure could create a risk of injury to persons, shall be protected against corrosion by painting, galvanizing, plating or by other equivalent means.

6.1.2.2 The requirement in 6.1.2.1 does not apply to bearings, laminations, or minor parts such as washers and screws, nor does it apply to a part where other specific requirements for materials or corrosion protection are noted.

6.1.2.3 Metals used in combinations shall be galvanically compatible.

6.1.2.4 Weatherproof units shall additionally comply with 45.1.

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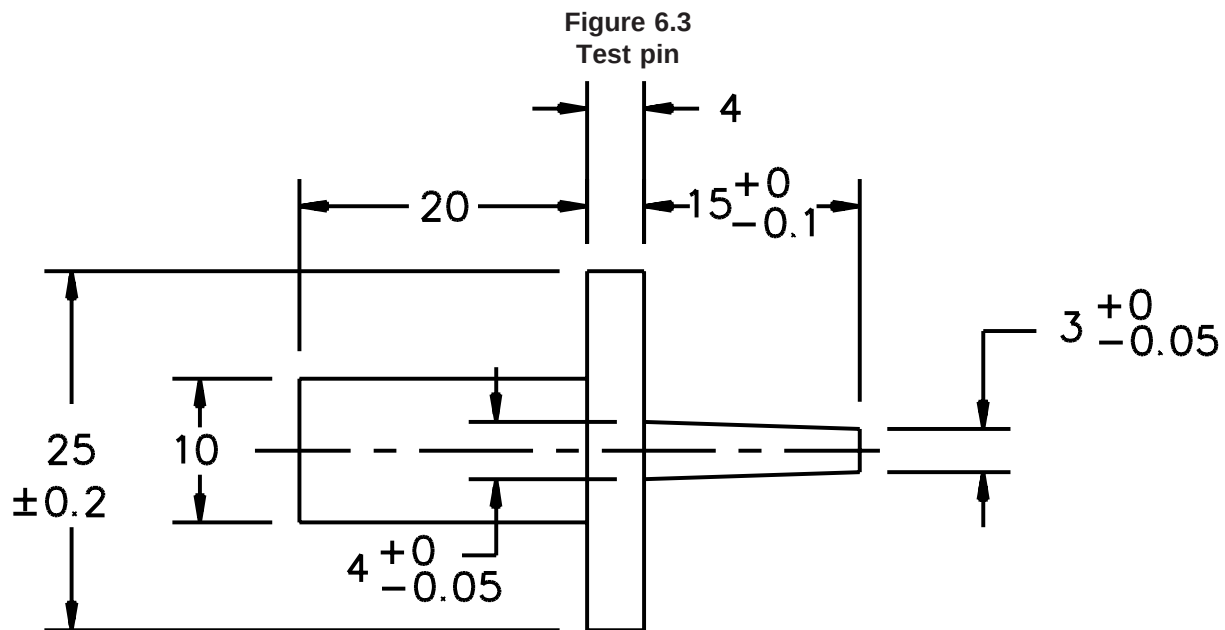
6.2 Accessibility of live parts

6.2.1 General

6.2.1.1 A live part that presents a risk of electric shock shall be located or enclosed so that protection against contact is provided.

6.2.1.2 The input impedance of the voltmeter used to measure voltage in accordance with the requirements of 6.2.2.2 is to be a minimum of 1 megohm. The input impedance of a meter with more than 1 megohm input impedance can be lowered by using shunt impedance.

6.2.1.3 A guard, baffle, or cover that can be removed without using a tool is to be removed when determining if a live part is accessible to the user. A live part that can be contacted by the articulated probe illustrated in Figure 6.1 or test pin illustrated in Figure 6.3 is considered to be accessible.



S2962

Dimensions in millimeters

6.2.2 Live parts other than exposed wiring terminals

6.2.2.1 The articulated probe and test pin illustrated in Figure 6.1 and Figure 6.3, respectively, when applied as described in 6.2.2.3, shall not contact any live part with a voltage greater than that specified in 6.2.2.2 with respect to the chassis or any other live part simultaneously accessible, in a different location, to the test pin or articulated probe.

6.2.2.2 The maximum voltages which may be accessible in accordance with 6.2.2.1 are:

- a) 21.2 volts peak for sinusoidal or nonsinusoidal DC,
- b) 30 volts for continuous DC, and
- c) 12.4 volts peak for DC interrupted at a rate of 200 Hz or less with approximately 50 percent duty cycle.

Exception: The voltage limits specified may be exceeded if the current through a 1500 ohm resistor connected between the accessible points does not exceed 0.5 mA.

6.2.2.3 The articulated probe and test pin referenced in 6.2.2.1 are to be applied with a force not exceeding 1 pound (4.4 N) to determine whether the live parts are accessible. The test pin shall not be applied to fuseholders and the like.

6.3 Sharp edges

6.3.1 An edge, a projection, and a corner of an enclosure, frame, guard, handle, or the like, shall be smooth and rounded, and not sufficiently sharp to constitute a risk of injury to persons in normal maintenance and use of a product.

6.4 Nonmetallic functional parts

6.4.1 Nonmetallic fan blades integral to the generator and other nonmetallic functional parts, failure of which may result in the likelihood of fire or personal injury, shall be suitable for the intended application and shall maintain a constant performance level when subjected to conditions of normal and abnormal use. Except as noted in 6.4.2, among the factors taken into consideration when the acceptability of a nonmetallic part is being judged are:

- a) Physical strength after being subjected to three impacts of 5 foot-pounds (6.8 J) on any surface that can be exposed to a blow during intended use. The impact is to be produced by dropping a smooth, solid, steel sphere 2 inches (50.8 mm) in diameter and weighing approximately 1.18 lbs (0.54 kg) from a height, H, of 51 inches (1.29 m).
- b) Resistance to ignition from electrical sources when tested in accordance with 3/4 Inch Flame Test as indicated in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.
- c) Resistance to distortion produced by forces during rotation and temperatures from normal and abnormal use during the Mold Stress-Relief Distortion Test as indicated in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

All of these factors are considered with respect to thermal aging.

6.4.2 A nonmetallic fan or other nonmetallic functional part outside the enclosure of a totally-enclosed generator need not be investigated with respect to resistance to ignition from electrical sources.

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6.5 Gaskets

6.5.1 Gasket material used to prevent the entrance of water during the Rain Test, Section 26, shall comply with the Gasket Tests, Section 27.

6.6 Foamed materials

6.6.1 Foamed materials, if provided, shall have a flame rating of 94V-2 minimum or equivalent.

MECHANICAL SYSTEM

7 Fuel Systems – Gasoline and Diesel

7.1 Tanks and pumps

7.1.1 A fuel tank provided as part of the engine-generator assembly shall be nonmetallic or constructed of painted mild steel having a minimum thickness of 0.030 inch (0.76 mm) or of material equivalent in strength, rigidity, and resistance to fire and corrosion. The joints shall be welded, brazed, soldered, or bonded. If soldered or bonded, the joints shall be of a construction which will retain the heads if the solder or bonding melts. Fittings and fill pipe, if soldered or bonded, shall be mechanically secured to the tank in addition to soldering or bonding.

7.1.2 Nonmetallic fuel tanks shall be subjected to Nonmetallic Fuel Tank Tests, Section 18.

7.1.3 When a tank is integral to the generator, the facilities for filling shall be such that spillage or leakage will be held captive or drain to the ground and not onto the electrical- or exhaust-system components. An Overspill Test (see 18.13) shall be conducted when the design of the engine-generator assembly may permit fuel to spill onto the engine compartment.

7.1.4 External fuel-confining parts of a fuel pump shall be of metal or shall be subjected to the exposure tests of 18.11. Failure of operating parts shall not result in external leakage of fuel. Electrically-operated fuel pumps shall comply with the requirements of Components, Section 4.

7.1.5 An automatic positive shutoff shall be provided in gravity-fed systems and shall prevent fuel at 3 pounds per square inch (psi) (20.7 kPa) or less from flooding the carburetor and spilling when the engine-generator is not operating.

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7.2 Fuel lines and fittings

7.2.1 Metal fuel lines shall be of annealed seamless drawn aluminum, steel, copper tubing, flexible tubing or hose. Flexible tubing or hose shall comply with 31.1.

7.2.2 Aluminum tubing shall have a nominal wall thickness of not less than 0.030 inch (0.0035 inch minus tolerance) [0.76 mm (0.089 mm minus tolerance)].

7.2.3 Copper tubing shall have a nominal wall thickness of not less than 0.032 inch (0.0025 inch minus tolerance) [0.81 mm (0.064 mm minus tolerance)]. Copper tubing 1/4 inch (6.4 mm) OD shall have a nominal wall thickness of 0.030 inch (0.0025 inch minus tolerance) [0.76 mm (0.064 mm minus tolerance)].

7.2.4 Steel tubing shall have a nominal wall thickness of not less than 0.028 inch (0.003 inch minus tolerance) [0.71 mm (0.08 mm minus tolerance)] and shall have a corrosion-resistant exterior coating equivalent to that afforded by paint.

7.2.5 Hose clamps shall be of the non-adjustable type.

7.2.6 Metallic fuel-line tubing fittings shall be of the type conforming to the Standard for Cast Copper Alloy Fittings for Flared Copper Tubes, ASME B16.26, or the equivalent.

7.2.7 High-pressure injection tubing shall conform with the following:

- a) The Hydrostatic Strength Test for Nonmetallic Fuel Hose Assemblies Used on the Outlet Side of the Fuel Pump, Section 29, with a test pressure of four times rated pressure,
- b) The Ground Fault Circuit Interrupter Evaluation and Durability Test, Section 25,
- c) The Tube-Fitting and Hose Connection Pull Test, Section 31, and
- d) Flexible tubing or hose shall conform with the Standard for Fuel and Oil Hoses, SAE J30.

7.2.8 Nonmetallic fuel-confining parts, except a gasket or seal, shall comply with requirements in 18.11. Glass filter bowls may be used where they are located within the framework of the generator.

7.2.9 Fuel lines shall be supported to minimize chafing and to maintain at least a 1/2 inch (12.7 mm) clearance from bare exhaust components. Electrical wiring shall not be tied to fuel lines and shall be routed so that it is not capable of inadvertently contacting fuel lines.

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7.3 Corrosion resistance

7.3.1 If corrosion of a ferrous part will interfere with the proper functioning of a part, the part shall be provided with a corrosion-resistant protective coating.

7.3.2 A part made of drawn brass or machined from brass rod containing more than 15% zinc shall be capable of withstanding, without cracking, the 10-Day Moist Ammonia-Air Stress Cracking Test, Section 30.

7.4 Carburetors

7.4.1 The carburetor shall be located so that overflow of gasoline due to excess choking will flow to ground and not contact electrical parts and exhaust system, or collect in an engine compartment.

7.4.2 A downdraft carburetor, if mounted over an engine and having an external float bowl vent opening, shall have a vent overflow tube to direct fuel away from the engine in case of fuel overflow.

7.4.3 A backfire deflector shall be provided for equipment employing mechanical ignition systems on each combustion air intake and, whether separate or a part of an air cleaner, shall conform with the requirements of Filter Element Flame Test, Section 28.

8 Fuel Systems – Liquefied Petroleum Gas

8.1 General

8.1.1 Where an LP-Gas fuel system is provided as part of the generator system it shall include the complete fuel system installed at the factory, except as indicated in 8.1.2.

8.1.2 Products equipped to use a removable fuel container may be shipped without the fuel container if a nameplate that identifies the correct fuel-container assembly to be used is attached adjacent to the container-mounting hardware.

8.1.3 Nonductile (regular gray iron) cast iron shall not be used for LP-Gas confining parts.

8.1.4 A body or fitting provided with tapered threads shall be threaded in accordance with the Standard for General Purpose Pipe Threads (Inch), ASME B1.20.1.

8.1.5 Vaporizers, regulators, valves, filters, and other fuel-system components subject to container pressure shall be of a type designed for use with LP-Gas at a working pressure not less than 250 psi (1.72 MPa).

8.1.6 Valves and connections on containers shall be protected or located within the profile of the generator to minimize the possibility of damage. Valves shall be protected to minimize the possibility of damage due to overturning, or other accidents.

8.1.7 All fuel-system components shall be fastened securely to minimize the possibility of loosening due to vibration.

8.2 Containers

8.2.1 A fuel container shall be a pressure vessel constructed, tested, and marked in accordance with:

- a) The ASME Unfired Pressure Vessel Code, or
- b) The U.S. Department of Transportation (DOT) Specifications for LP-Gas Containers.

8.2.2 A fuel container may be fixed to or removable from the generator unit.

8.2.3 An ASME fuel container shall have a designed working pressure of 312, 343, or 375 psi (2.15, 2.36, or 2.59 MPa). It shall be marked with the ASME "U" symbol and the design working pressure.

8.2.4 A DOT fuel container shall be constructed, tested, and marked for a minimum service pressure of 240 psi (1.65 MPa). It shall bear the marking DOT-4B240, DOT-4BA240, DOT-4BW240, or DOT-4E240.

8.2.5 A fuel container shall be so located as to minimize the possibility of damage to the container or its fittings. The fittings of a removable container shall be protected to minimize the possibility of damage during removal, filling, and replacement.

8.2.6 A fuel container shall be secured in place so as to meet the requirements of the LP-Gas Container Load Tests, Section 33.

8.2.7 A removable fuel container shall be designed to engage a substantial positioning pin or an equivalent means for proper positioning of the container when reinstalled so that the relief valve is not directed toward operator controls or hot engine parts.

8.2.8 If a removable fuel container is used, means shall be provided in the fuel system to minimize the escape of fuel when the container is changed.

8.2.9 The use of a quick-closing coupling (a type closing in both directions when uncoupled) in the fuel line shall be considered as complying with the requirements of 8.2.8.

8.2.10 Welding, if necessary, shall be made only on saddle plates, lugs, or brackets originally attached to the container by the manufacturer.

8.2.11 A fuel container from which vapor only is to be withdrawn shall be installed and equipped with connections arranged to minimize the accidental withdrawal of liquid.

8.2.12 A fuel container shall be shielded, if necessary, against direct heat radiation from the engine and exhaust system. See Table 19.2.

8.2.13 A removable-type container shall have the protection means for the fittings permanently attached to the container.

8.2.14 An excess-flow and a back-pressure check valve, if required, shall be located inside the container.

8.2.15 The filling connection shall be fitted with a double back-pressure check valve, or a hand-operated shutoff valve and a back-pressure check valve.

8.2.16 A removable container may employ a hand-operated shutoff valve with an internal excess-flow check valve.

8.2.17 An accessible hand operated shutoff valve shall be provided on the container for each liquid or vapor fuel supply line.

8.2.18 An automatic excess flow check valve shall be provided in each container connection having an opening for the flow of gas in excess of a No. 54 drill size, 0.055 inch (1.40 mm); except those connections for filling and safety relief valves.

8.3 Gauges

8.3.1 A variable liquid-level gauge (such as a slip-tube or rotary type) which requires venting of fuel to the atmosphere shall not be used on a fuel container.

8.3.2 A fixed-tube gauge shall be employed on the fuel container, except as indicated in 8.3.3.

8.3.3 A removable container filled by weight only is not required to employ a fixed-tube gauge.

8.3.4 The length of a fixed-tube shall be such that, when the lower end touches the surface of the liquid in the container, the volume of the contents will not exceed 80% of the total container volume. This condition shall be met on a removable container regardless of whether the container is being filled in the horizontal or vertical position.

8.3.5 ASME containers shall have, permanently attached to the container, adjacent to the fixed liquid level gauge, or on the container nameplate, markings showing the percentage full that is indicated by the gauge.

8.3.6 Each container, whether constructed to ASME or DOT specifications, equipped with a fixed liquid level gauge for which the tube is not welded in place shall be permanently marked adjacent to such gauge or on the container nameplate as follows:

- a) Containers designed to be filled in one position shall be marked with the letters "DT" followed by the vertical distance [to the nearest tenth inch (2.5 mm)] measured from the top center of the container boss or coupling into which the gauge is installed to the maximum permitted filling level. The exterior of the removable dip tube gauging device shall bear a corresponding "DT" marking.
- b) Portable universal type containers that may be filled in either vertical or horizontal position shall be marked as follows:
 - 1) For Vertical Filling – With the letters "VDT" followed by the vertical distance (to the nearest tenth inch), measured from the top center of the container boss or coupling into which the gauge is installed to the maximum permitted filling level.
 - 2) For Horizontal Filling – With the letters "HDT" followed by the vertical distance (to the nearest tenth inch), measured from the center line of the container boss or coupling opening into which the gauge is installed to the inside top of the container when in the horizontal position.

8.3.7 A nonventing, indicating-type liquid-level gauge (such as magnetic type) shall be provided on each container.

8.4 Fuel lines and fittings

8.4.1 All piping from a fuel container to the first-stage regulator shall be iron, steel (black or galvanized), brass, or copper pipe; seamless copper or steel tubing; flexible LP-Gas hose; or other equivalent piping means.

8.4.2 Steel tubing shall have a minimum wall thickness of 0.049 inch (1.24 mm) and shall have a corrosion-resistant exterior coating. Paint is considered to be an acceptable corrosion-resistant coating. Copper tubing shall have a minimum wall thickness of 0.032 inch (0.81 mm) and shall be annealed. Aluminum piping or tubing shall not be used.

8.4.3 A length of flexible hose of a type designated for use with LP-Gas shall be employed between a removable container and any fixed fuel-system parts, and between any high-pressure parts on the frame and parts which are mounted on the engine.

8.4.4 Tubing fittings shall be of a type designated for use with LP-Gas.

8.4.5 Hose fittings shall be of a type for use with the LP-Gas hose employed.

8.4.6 Cast fittings shall not be employed for either piping or tubing.

8.4.7 Fuel lines shall be supported to minimize chafing and to maintain at least a 1/2 inch (12.7 mm) clearance from bare exhaust components. Electrical wiring shall not be tied to fuel lines and shall be routed so that it is not capable of inadvertently contacting fuel lines.

8.4.8 Flexible hose passing through sheet metal shall be installed to minimize hose abrasion, such as by use of clamps and grommets.

8.4.9 All pipe threaded fuel system fittings, including container fittings, shall be assembled using a pipe joint sealing compound designed for use with LP-Gas. All fuel-system connections, including the container with associated valves and fittings, shall be tested for leaks with a soap and water solution or equivalent while the system is under LP-Gas pressure of not less than 90 psi (621 kPa).

8.4.10 The fuel container and associated valves and fittings may be tested separately using air pressure of not less than 90 psi (621 kPa).

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8.5 Vaporizers

8.5.1 Each vaporizer shall have a valve or plug located at or near the lowest portion of the section occupied by the water or other heating medium which will permit substantially complete draining of the vaporizer.

8.5.2 Each vaporizer shall be marked with the design working pressure in pounds per square inch gauge (kPa) and with the water capacity of the fuel-containing portion in pounds (kg).

8.5.3 Engine exhaust gases shall not be used as a direct means of heat supply for the vaporization of fuel unless the materials used for parts of the vaporizer in contact with the exhaust gases are resistant to the corrosive action of exhaust gases and the vaporizer system is designed to prevent excessive pressure.

8.5.4 Vaporizers shall not be equipped with fusible plugs.

8.6 Safety control and relief devices

8.6.1 A spring loaded internal-type safety relief valve with proper start-to-discharge setting and flow capacity, as detailed in 8.6.2 – 8.6.7, shall be provided on the fuel container.

8.6.2 A safety relief valve to be used on an ASME container shall be set, sealed, and marked with a start-to-discharge pressure not higher than the marked design working pressure of the container, and not less than 88% of the marked design working pressure of the container.

8.6.3 A safety relief valve on an ASME container shall be marked with its discharge capacity in cubic feet (cubic meters) per minute of air in accordance with Table 8.1 which relates the minimum required flow capacity to the outside surface area of the container.

Table 8.1
Safety relief valve capacity

Container surface area		Minimum flow rate of air	
Square feet	Square meters	CFM	m ³ /min
20 or less	1.86	626	17.7
25	2.32	751	21.3
30	2.79	872	24.7
35	3.25	990	28.0
40	3.72	1100	31.4

8.6.4 A safety relief valve on a DOT container shall be set for a start-to-discharge pressure of 375 psi (2.59 MPa) and shall comply with the DOT regulations.

8.6.5 A safety relief valve shall have direct communication with the vapor space of the container.

8.6.6 The outlet from a container safety relief device shall discharge to the outside of enclosed spaces and as far as practicable from possible sources of ignition. A loose-fitting rain cap shall be provided on the end of discharge outlet piping. The cap shall be attached to prevent its being lost.

8.6.7 If a discharge line from the container safety relief device is used, it shall be of metal (other than aluminum), sized and located so as not to restrict the required flow of gas from the safety relief device. Such a discharge line shall be so constructed and installed as to minimize the possibility of its being dislodged by the discharge from the safety relief device and shall be directed upward within 45 degrees of the vertical.

8.6.8 An automatic shutoff valve shall be provided in the fuel system at some point ahead of the inlet of the first-stage regulator, designed to prevent flow of fuel when the ignition is off and the engine not running or if the engine should stop. This device shall permit the back flow of fuel from the vaporizer in the event of a pressure build-up in the vaporizer. The device shall be of a type designed for use with LP-Gas at a working pressure of not less than 250 psig (1.72 MPa).

8.6.9 An automatic switch, such as an oil-pressure switch or vacuum switch, provided to control the automatic shutoff valve shall be rated for the load controlled and shall be of a type which is designed for the intended use.

8.6.10 A hydrostatic relief valve shall be installed between the container shutoff valve and the automatic shutoff valve of a liquid withdrawal system. The relief valve shall be set to discharge at not higher than 500 psig (3.45 MPa) nor lower than 400 psig (2.76 MPa). The valve discharge shall be arranged to vent outside of the system enclosure.

8.6.11 Automatic pressure-reducing equipment incorporating an automatic shutoff means to prevent the passage of fuel when the engine is not running shall be employed.

8.7 Nonmetallic parts

8.7.1 A synthetic-rubber part in contact with LP-Gas shall not show excessive volume change or loss of weight, when considered on the basis of its intended function, following immersion for 70 hours in hexane.

8.7.2 A change in volume of not more than 25% swelling or 1% shrinkage, and a weight loss (extraction) of not more than 10% is considered as indicating compliance with 8.7.1.

8.7.3 A part made of synthetic rubber which may be affected by aging shall not crack or show visible evidence of deterioration following exposure in an air oven for 70 hours at $100 \pm 2^\circ\text{C}$ ($212 \pm 3.6^\circ\text{F}$).

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8.8 Corrosion resistance

8.8.1 If corrosion of a ferrous part will interfere with the proper function of a part, the part shall be provided with a corrosion-resistant protective coating.

8.8.2 A part made of drawn brass or machined from brass rod shall be capable of withstanding, without cracking, 10-Day Moist Ammonia-Air Stress Cracking Test, Section 30.

9 Exhaust System

9.1 Engine-generators shall have complete exhaust systems and guarding in accordance with the requirements of this outline of investigation. Mufflers shall be qualified by the U.S. Department of Agriculture as a spark arrester for internal combustion engines per USDA-Forest Service Standard 5100-1C or a separately-qualified component add-on arrester shall be factory-installed in the exhaust system or shall be shipped with the unit as an accessory with instructions and precaution for the user to install the add-on arrester(s). The instruction manual (Section 43) shall indicate spark arrester maintenance and replacement requirements.

9.2 The muffler shall be located within the contour of the protective frame so that it will be positioned to prevent personal injury from unintentional contact with hot parts in accordance with 19.6.

9.3 Exhaust components of ferrous sheet, pipe, or tubing materials shall be constructed to assure strength, rigidity, and durability and shall also be protected against corrosion by painting, galvanizing, plating, or by other equivalent means. Compliance is checked by visual inspection and tested in accordance with Impact Tests, Section 20, Load Test, Section 22, and Ground Fault Circuit Interrupter Evaluation and Durability Test, Section 25.

ELECTRICAL SYSTEM

10 Enclosure

10.1 General

10.1.1 A generator shall be so formed and assembled that it will have the strength and rigidity necessary to resist the abuses to which it may be subjected, without increasing the risk of fire or accident due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other serious defects.

10.1.2 For unreinforced, flat surfaces in general, cast metal shall be not less than 1/8 inch (3.2 mm) thick, except that malleable iron may be not less than 3/32 inch (2.4 mm) and die-cast metal may be not less than 5/64 inch (2.0 mm) thick. See 10.1.9. Corresponding thicknesses not less than 3/32, 1/16, and 3/64 inch (2.4, 1.6, and 1.2 mm), respectively, may be acceptable if the surface under consideration is curved, ribbed, or otherwise reinforced, or if the shape or size or both of the surface is such that adequate mechanical strength is provided. Also see 10.1.3.

10.1.3 An enclosure of sheet metal is judged with respect to its size, shape, thickness of metal, and its suitability considering its intended function. The use of sheet steel less than 0.026 inch (0.66 mm) thick if uncoated or less than 0.029 inch (0.74 mm) thick if galvanized or of nonferrous sheet metal having an average thickness less than 0.036 inch (0.91 mm) is not allowed, except for relatively small areas or for surfaces that are curved or otherwise reinforced.

10.1.4 When a nonmetallic enclosure is used the enclosure shall:

- a) Be constructed of V-0, V-1, 5V material which meets the requirements of the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, or shall comply with Flammability – 20 mm (3/4 Inch) Flame Test as indicated in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, except the test samples are to be temperature-conditioned only,
- b) Shall comply with Resistance to Impact Test as indicated in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, and
- c) Shall comply with Mold Stress-Relief Distortion Test as indicated in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

10.1.5 Sheet metal to which a wiring system is to be connected shall be not less than 0.030 inch (0.76 mm) thick if uncoated steel, not less than 0.034 inch (0.86 mm) thick if galvanized steel, and not less than 0.045 inch (1.14 mm) thick if nonferrous.

10.1.6 Determination of the acceptability of the size, number, and location of openings in an enclosure shall include consideration of the following factors:

- a) Environment,
- b) Degree of exposure,
- c) Protection against accidental contact with live parts, including enameled wire, and
- d) Prevention of the expulsion of molten metal, burning insulation, flaming particles, and the like, onto flammable materials, if applicable.

10.1.7 Electrical parts of the generator shall be located or enclosed so as to provide protection against accidental contact with uninsulated live parts having peak voltages above 42.4 volts. Insulated brush caps do not require additional enclosure.

10.1.8 The parts of enclosures and guards which may be removed by the user without the use of tools shall be removed before determination of compliance with the requirements of 10.1.7.

10.1.9 Openings, other than those for wiring connections, in the enclosure of a generator shall conform to the requirements given in 6.1.1.4.

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10.2 Batteries

10.2.1 Batteries provided as part of the engine-generator assembly shall be:

- a) Secured in position,
- b) Positioned or shielded to prevent accidental short circuit from conductive materials or tools or parts of the engine-generator,
- c) Accessible for replacement,
- d) Readily accessible for maintenance, and
- e) Installed at least 3 inches (76.2 mm) away from arc-producing devices (e.g., switches and relays) unless the battery is a sealed non-maintenance type.

10.2.2 Battery compartments provided without an installed battery or provided separately as an accessory shall be provided in accordance with 10.2.1 for the battery type(s) intended for use.

10.3 Battery compartment

10.3.1 When a separate lead-acid storage battery is provided as part of the engine-generator assembly, means shall be provided to secure it in a position to prevent contact with conducting materials in the area and it shall be located to permit ready access to the cell openings for servicing, except for batteries which do not require service.

10.3.2 There shall be no sparking or arc-producing devices located within 3 inches (76.2 mm) of the battery (e.g., switches, relays).

11 Electric Shock

11.1 Voltage

11.1.1 A live part is not considered to be a risk of electric shock if the voltage of the part does not exceed the values specified in Table 11.1.

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Table 11.1
Risk of electric shock – maximum acceptable voltage

Voltage type	Voltage
1. Sinusoidal, AC	15 V, rms
2. Nonsinusoidal, AC	21.2 V, peak
3. Pure DC	30 V
4. DC interrupted at a rate of 10 to 200 Hertz	12.4 V, peak

11.2 Stored energy

11.2.1 The allowable capacitance between capacitor terminals that are accessible shall satisfy the following expressions:

$$V < 367 \text{ where } 2.67 \leq C < 13.9$$

$$V < 2314 C^{-0.7} \text{ where } 13.9 \leq C < 497$$

$$V < 30 \text{ where } C \geq 497$$

In which:

C is the capacitance of the capacitor in microfarads, and

V is the voltage across the capacitor in volts. V is to be measured 5 seconds after the capacitor terminals are accessible by the removal or opening of a cover, or the like. Typical calculated values appear in Table 11.2.

Table 11.2
Risk of electric shock – stored energy current

Capacitance in microfarads	Maximum allowable voltage across the capacitor, in volts
2.67 to 13.9	367
20.0	284
50.0	150
100.0	92.1
184.5	60.0
200.0	56.7
497.0 or more	30.0

12 Limited Energy Circuit

12.1 One or more resistors or a regulating network used to limit the current shall be such that the current under any condition of load including short circuit does not exceed:

- a) The voltage limits specified in Table 12.1, and
- b) 8 amperes for 0 – 42.4 volts peak AC, or 0 – 30 volts DC.

Table 12.1
Rating for fuse or circuit protector

Circuit voltage (volts)	Maximum overcurrent protection (amperes)
0 – 21.2 (peak) 0 – 15 DC	5
21.3 – 42.4 (peak) 15 – 30 DC	3.2

13 Assembly

13.1 A generator shall be so assembled that it will not be adversely affected by the vibration of normal operation. Brush caps shall be tightly threaded or otherwise constructed to prevent loosening.

13.2 A switch, an attachment plug receptacle or similar component shall be mounted securely and, except as noted in 13.3, shall be prevented from turning. See 13.4.

13.3 The requirement that a switch be prevented from turning may be waived if all four of the following conditions are met:

- a) The switch is of a plunger or other type that does not tend to rotate when operated. A toggle switch is considered to be subject to forces that tend to turn the switch during the normal operation of the switch.
- b) Means for mounting the switch make it unlikely that operation of the switch will loosen it.
- c) Spacings are not reduced below the minimum acceptable values if the switch rotates, and leads or connections thereto, or both, are not stressed.
- d) Normal operation of the switch is by mechanical means rather than by direct contact by persons.

13.4 The means for preventing the turning mentioned in 13.2 is to consist of more than friction between surfaces. A lock washer, properly applied, is acceptable as a means for preventing a small stem-mounted switch or other device having a single-hole mounting means from turning.

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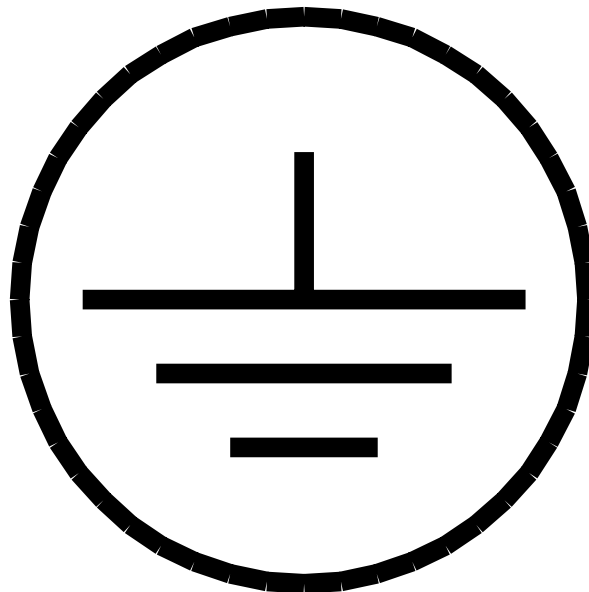
14 Wiring

14.1 Equipment grounding terminals

14.1.1 A terminal intended for the connection of an equipment grounding conductor shall be identified by:

- a) Use of a wire-binding screw with a green-colored head that is slotted or hexagonal, or both, or
- b) Use of a threaded stud with a green-colored hexagonal nut, or
- c) Use of a green-colored pressure-terminal connector, or
- d) Being marked G, GR, GRND, Ground, Grounding, or the like, or
- e) A marking on a wiring diagram provided on the product, or
- f) The grounding symbol illustrated in Figure 14.1 on or adjacent to the terminal or on a wiring diagram provided on the product.

Figure 14.1
Symbol for equipment grounding conductor



IEC Publication 417, Symbol 5019

14.1.2 With reference to 14.1.1 (f), the following requirements apply when the symbol illustrated in Figure 14.1 is used:

- a) The information described in 43.1.7 (c) shall be provided in the instruction manual, and

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